ELEMENTS OF CHEMISTRY,

AND

NATURAL HISTORY.

TO WHICH IS PREFIXED

THE PHILOSOPHY OF CHEMISTRY.

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ELEMENTS

OF

NATURAL HISTORY

AND

CHEMISTRY.

PART III.

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Of Iron.

IRON, to which the alchemiſts gave the name of *Mars*, is an imperfect metal, of a livid white colour inclining to grey, and diſpoſed in ſmall facets. It is ſuſceptible of a very fine poliſh, and may be made very brilliant. It is ſo hard and elaſtic, as to be capable of deſtroying the aggregation of any other metal.

Iron emits a ſmell, eſpecially when it is rubbed or heated. It has likewiſe a very ſtrong ſtiptic taſte, which acts powerfully on the animal œconomy.

Iron is, next after tin, the lighteſt of all metallic ſubſtances. A cubic foot of forged iron weighs five hundred and eighty pounds. It may be hammered into plates; but being very hard, and liable to become much harder under the hammer, it cannot be beat into leaves. Its ductility, when drawn into wire, is much more conſiderable: it is drawn into very fine threads, which are uſed as ſtrings to harpſichord keys. This property appears to depend on its tenacity. Iron is in fact the moſt tenacious of all metals, next after gold. A thread of iron one tenth of an inch in diameter is ſufficient to ſupport, without breaking, the weight of four hundred and fifty pounds.

Pure iron has a peculiar cryſtaline form. In furnaces in which iron has been ſlowly cooled, there are found quadrangular pyramids articulated and branched, and conſiſting of octohædrons inſerted one into another. We owe this obſervation to M. Grignon, maſter of the forges at Bayard in Champagne. Laſtly, beſide all the properties which iron poſſeſſes in common with other metallic ſubſtances, this metal exhibits three properties which are entirely peculiar to itſelf. One of theſe is magnetiſm, or the property of being liable to be attracted by the loadſtone, and of acquiring the virtues of the loadſtone, either when it has remained long in an elevated ſituation; or in a direction between north and ſouth; or when it has been employed as a conductor to the electric fire of thunder, as is evinced by a variety of facts; or when two pieces of iron are ſmartly rubbed one upon another. The ſecond of the ſingular properties of iron, is that of taking fire, and melting ſuddenly when ſtruck with a flint; a phænomenon to which the poets

poets unanimously ascribe the first discovery of fire. The third property by which it is distinguished, is that of being found with manganese in plants and animals; some of whose juices derive from it their colour: it is even probable that those organic beings themselves form the metal; for plants growing in pure water contain iron, which may be obtained from their ashes.

Iron is a metal which abounds very much in nature; for, independently of what plants and animals contain, it is found in almost all coloured stones, in bitumens, and in most metallic ores. But here we are to treat only of such mineral matters as contain a great deal of iron, and are wrought for the purpose of extracting the metal from them. In these ores, which are very numerous, iron exists either in a metallic state, or in the state of an oxide, or mineralized by different substances.

1. Native iron is distinguished by its colour and malleability. It is very rare, and is only found accidentally in iron ores. Margraf found it in a fibrous form at Eibenstock in Saxony: Dr Pallas has discovered, in Siberia, a mass amounting to 1600 pounds; and M. Adanson asserts, that it is common in Senegal. Some mineralogists think that those specimens of native iron are products of art, and have been on different occasions buried under ground.

2. Ores of black iron, taken in general, seem all to belong to an oxide of black iron, more or less pure.

Black iron is distinguishable by its colour, by its property of being more or less susceptible of attraction by the loadstone, and by being altogether insoluble in acids. This iron is sometimes crystalized in the shape of polyhædrons, or round plates, and presents different

ſhades of the moſt brilliant changing colours; ſuch is that from the iſland of Elba. It there forms a conſiderable mountain, which is wrought above ground. The ore from Sweden is likewiſe a black iron, but not cryſtallized; it conſiſts of maſſes, more or leſs ſolid, mixed with quartz, ſpar, aſbeſtos, &c. It is frequently ſo hard, as to admit of a poliſh, and its ſurface appears like a mirror. Thus it, as well as the former, has obtained the name of *ſpecular iron*: it is found united in conſiderable quarries. This iron varies in the degree of its colour: ſome is perfectly black, which is highly ſuſceptible of attraction by the loadſtone; ſome bluiſh, which is leſs ſo; and ſome grey, which poſſeſſes this property in a very ſmall degree. The iron of Norway is likewiſe a black iron; but it is generally in ſmall ſcales, like mica, often mixed with garnets and with ſhorls. Black iron is ſometimes found in grains. It is likewiſe cryſtallized in cubes; which has made ſome naturaliſts give it the name of *galena* of *iron*, or *eiſen-glanz*. When micaceous iron ore is of a black colour, it is called *eiſen-man*; eſpecially if the ſcales be very large. When theſe ſcales are red, and covered with duſt of the ſame colour, it gets the name of *eiſen-ram*. The ſpecies of iron ore in black octohædral cryſtals very regular and diſperſed in a kind of ſchiſtus, or hard ſteatite, which comes from Sweden, Corſica, &c. ſeems to belong to this claſs of iron ores. It is attracted by the loadſtone, and very brittle. The lamellated brilliant iron of Framont belongs alſo to this ſpecies.

Though the ſeveral ſpecies of black iron ores, which I have joined together in this article, ſeem to bear an evident analogy with one another, ſeveral mineralogiſts have regarded them as very different, and have arranged

 them

them ſeparately. This variety of opinions originates from our not yet having ſufficient knowledge of their nature. It ſhould ſeem, that of theſe ores ſome approach nearer to the metallic ſtate, as the octohædral iron of Corſica and Sweden, which M. Monge compares to martial ethiops. This ſpecies is ſtrongly attracted; others, on the contrary, approach nearer to the ſtate of oxides, as the iron of the iſland of Elba, and particularly the *eiſen-man*, and *eiſen-ram*, which are not liable to be attracted by the loadſtone. The ores of the iſland of Elba appear to be only black oxides of iron produced from carbonate of iron reduced by means of fire. In this way M. Vauquelin has imitated them with great ſucceſs. To this account of black irons, I ſhall here ſubjoin ſome obſervations made by the Abbe Haüy, of the academy of ſciences. He diſtinguiſhes two primitive ſhapes of theſe irons, which, according to him, announce two ferruginous ſubſtances of different natures.

One is a regular octohædron. To this belongs the iron of Corſica. The cryſtals of this ſpecies are ſtrongly attracted by the magnetic bar. The ſpecular iron ore from the golden mountain, in octohædral ſegments, is a variety of this ſpecies.

The other is the ſhape of a cube. To this laſt belongs particularly the iron ore of the iſland of Elba, of which there are two principal varieties, namely, 1. iron in rhomboids, very obtuſe; 2. iron with ſix pentagons, and eighteen triangles. Theſe varieties are but feebly attracted by the magnetic bar. By filing, M. Haüy obtained from them a reddiſh unctuous powder, ſimilar to that of red micaceous iron, or the eiſen-ram of the Germans.

3. Iron is very often in the ſtate of ruſt, more or leſs oxidated. It then forms ochraceous iron ores. All earths coloured brown or red are of this kind.

4. We muſt beware of confounding with ochres thoſe iron ores which are called *bog ores.* They do, indeed, contain oxidated iron; but that oxide is combined with carbonic acid, and with phoſphoric acid, which appears to have been produced by the decompoſition of vegetables. Bog irons are diſtinguiſhed into rich and poor, fuſible and dry. The rich is only iron a little ruſted, and contains but a very ſmall proportion of earth. Fuſible iron melts very eaſily, and affords caſt iron of a good quality; the metal being in it united only to ſome ſtones which eaſily melt. Dry iron is more calcined, and mixed with ſome very refractory ſubſtances. All bog iron, in general, is uſually arranged in layers, like ſtones, and appears evidently to have been depoſited by water. It is often in the form of pebbles, or flat irregular ſpherical bodies. Organic matters, ſuch as wood, leaves, barks, ſhells, are not unfrequently met with in the ſtate of bog iron. This kind of tranſmutation ſeems to ſuggeſt the idea, that there is ſome analogy between iron and organic bodies. A portion of phoſphate of iron, contained in theſe, which abound more than any other iron ores, communicates to this metal the property of being brittle when cold. Bergman, who was acquainted with iron in this ſtate, but did not determine its nature, called this phoſphate of iron *ſiderites*; ſome German chemiſts have ſince called it *water iron.* We will afterwards explain how this ſalt may be ſeparated from iron that is brittle when cold.

5. The eagle ſtone, or *ætites*, is a variety of bog iron.

Eagle

Eagle ſtones are bodies of various forms, commonly oval or polygonous, conſiſting of concentric layers, diſpoſed around a nucleus, which is often moveable in the centre of the ſtone. The drying and contraction of theſe layers has formed a cavity in the middle, in which ſome fragments of various ſizes float at liberty. This ſtone has received its name from an opinion, that eagles put it into their neſts, and that it helps them to lay their eggs more eaſily, and promotes the effects of incubation. It has been hence inferred, that this ſtone would act powerfully on the fœtus in the mother's womb. Some authors go ſo far as to aſſert, that the pains of a lying-in woman may be brought ſooner on by binding an eagle ſtone to her thigh, and kept back by binding it to her arm.

6. The *hæmatites* is a kind of bog iron, which appears to be formed in the ſame manner as ſtalactites. It derives its name from its colour, which is commonly red like blood, though ſubject to varieties. The hæmatites uſually conſiſts of layers covering one another, and compoſed of convergent needles. The ſuperficies of this ore is covered over with tubercles. Hæmatites are diverſified, not only by colour, but by form too. There is, for inſtance, the needled hæmatites, the hæmatites in bunches of grapes, or *hæmatites botrytis*, &c. Theſe ores are pretty often found with muddy iron; and are depoſited on a great many different bodies.

7. The *loadſtone* is nothing elſe but an ochraceous iron ore, very hard and very refractory; which, however, ſome perſons think not very remote from the metallic ſtate. It is known by its property of attracting filings of ſteel. It is found in Auvergne, and in Biſcay in Spain. It is diſtinguiſhed by the diverſities of its colour into ſeveral varieties.

8. *Emery, smyris*, is a grey or reddish iron ore, considered by a number of mineralogists as a kind of hæmatites. It is very hard and refractory: great plenty of it is found in the isles of Jersey and Guernsey. It is ground in mills into a powder, and used in this form for polishing glass and metals.

9. *Sparry iron* is an oxide of iron in combination with carbonic acid, and transported by water. It is usually of a white colour; but there are specimens of this ore stained with almost every different colour, grey, yellow, red. It is always in plates of various sizes, and semi-transparent like spar. It is of considerable gravity, and is often regularly crystallized: it is found in considerable quarries, often mixed with pyrites, as for instance at Allevard in Dauphiny; sometimes it is mixed with grey silver ore, as the iron of Baigorry; and sometimes with manganese, as that of Styria. Some chemists think it to be a spar in which the metallic oxide has been deposited. Sparry iron is decomposed by itself in close vessels; and it then yields carbonic acid. What remains is a brilliant black iron, subject, in a high degree, to the attraction of the loadstone, and which may be easily melted by the action of a strong fire. The manganese which it frequently contains, renders it liable to be altered by the action of air, and makes it take a brown colour, as it loses its form and consistency.

10. Nature likewise presents us with iron in a saline state, combined with the sulphuric acid, and forming sulphate of iron, or green copperas. This salt is found in the galleries of iron mines, especially in such as contain *pyrites*. It is sometimes found in green crystals, or in the form of beautiful stalactites: on other occasions, again

again, it is not so pure, but appears to have suffered some alteration. If it has lost only the water of its crystallization, it is of a white or a greyish colour: it is then called *sori*. When somewhat more thoroughly calcined, it is yellow, and is called *missy* If the calcination has been carried so far as to drive off a considerable part of the acid, the sulphate of iron is then red, and bears the name of natural *colcothar*, or *chalcite;* when mixed with inflammable matters, this salt is called *melanteri*, from its black colour. All these matters have received the common name of *atramentarious* stones, as being, no less than sulphate of iron, proper materials for making ink.

11. Iron is often found in combination with sulphur; it then forms *martial pyrites*. This ore has received the name of pyrites, because it is hard enough to afford a great abundance of sparks when struck with steel. We call this combination native sulphur of iron. Martial pyrites are commonly in small round masses, which are sometimes regular. They are most generally spherical, cubic, or duodecahædral. Their form is subject to many varieties; a fact which the reader of Henckel's Pyritology cannot fail to be convinced of.

The abbe Haüy, who has paid much attention to the structure of ferruginous *pyrites*, has discovered the following principal varieties in their shape.

1. The *smooth cube:* this is the primitive form of this mineral.

2. *Pyrites* in regular octahædrons.

3. *Pyrites* in cubo-octahædrons: this is the cube with truncated angles.

4. *Duodecahedral pyrites* with pentagonal sides.

5. *Cubical pyrites* striated on three sides.

He has ſhown that the cube, whoſe ſtriæ ſo much embarraſſed Stenou and Mairan, by the diverſity of their directions, was nothing but a modification produced by a haſty cryſtallization of the duodecahædron, with pentagonal ſides.

6. *Pyrites* with twenty triangular faces, eight of which are equilateral, and twelve iſoſecles.

7. *Pyrites* with thirty-ſix triangular iſoſceles faces twelve of which are broader and longer than the other twenty-four.

8. *Globular pyrites* ſet with octahædral points; this ſeems to be of a different nature from the preceding.

Some pyrites are externally brown and iron coloured; the greater part are yellowiſh, and even at the ſurface pretty much like copper ores. They are all yellow, and of a copper appearance within; and they conſiſt moſtly of needles, or pyramids of a number of ſides, with their ſummits converging towards a common centre. Pyrites are uſually diſperſed near beds of iron ore, and ſcattered among clays, and through coal mines. The uppermoſt ſtratum of a coal mine is almoſt always pyritous. All pyrites are eaſily decompoſed. No ſtrong heat is requiſite to drive off the ſulphur which they contain. They almoſt all alter of themſelves when expoſed to the air, eſpecially if the ſituation be moiſt: they ſwell, break, loſe their luſtre, and are covered over with a greeniſh white efflorefcence, which is nothing elſe but ſulphate of iron. It appears that this alteration, which has been called the *vitriolization of pyrites*, depends on the joint action of air and water on the ſulphur. Sulphuric acid is thus formed; which, diſſolving the iron, riſes above the pyrites in a form reſembling vegetation,

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by ſeparating gradually the ſmall pyramids of which the mineral conſiſts. But all pyrites do not effloreſce with the ſame facility. The globulous pyrites, the colour of which is very pale, and the contexture not very cloſe, effloreſce the readieſt. Such as are of a bright copper yellow, and conſiſt of ſmall plates very neatly arranged one over another, effloreſce not without great difficulty, and ſhould be carefully diſtinguiſhed from the former, as they differ from them in colour, form, texture, and other properties.

12. Iron is likewiſe met with in combination with arſenic, and both of them in a metallic ſtate. This ore, which is true *miſpickel*, is white, ſparkling, granulated, or with facets, and does not, like the arſenical pyrites, properly ſo called, contain any ſulphur. Wolfram was formerly thought to be arſenical iron ore; but is now known to be tungſten ore.

13. Iron is ſometimes found in the form of a blue powder; ſometimes of a brighter, and ſometimes a deeper colour. In this ſtate it is called *native Pruſſian blue.* It is mixed with vegetable earths, particularly peat-earth.

14. Laſtly, as iron is more plenteous than any other metal, it is often found mixed with ſand, clay, or chalk; and a great many earths and ſtones are coloured by it.

Iron ores are aſſayed in the dry way in the following manner: After being reduced to powder, they are mixed with twice their own weight of pounded glaſs, one part of calcined borax, and a little powdered charcoal; this mixture is well triturated: it is then put into a crucible, with a little marine ſalt added to cover the crucible, and urged with fire till it melt. When the whole becomes perfectly cool, it is fouud to contain a

ſmall

ſmall ſpherical button of iron, often cryſtallized at the ſurface, and more or leſs malleable.

Bergman propoſes the aſſaying of iron ores in the humid way. He employed the muriatic acid to diſſolve iron, and precipitated it by an alkaline pruſſiate. When there were other metals mixed with the iron, he calcined and ſeparated them by the nitric and the acetous acids; and after that diſſolved the iron by the muriatic acid.

The treatment of iron ores is varied according to the ſtate of the metal. Some ores need no preparation before they be melted; others muſt be pounded and waſhed, ſometimes even roaſted, to render them ſoft and fuſible.

Muddy iron and ſparry iron are wrought in the ſame way; both being melted on coals. The furnaces uſed in melting iron vary in height from twelve to eighteen feet. Their cavity is in the form of two quadrilateral pyramids, with their baſes joined nearly at the middle of the height of the furnace: this cavity is called (in French) *etalage*. A hole, through which the metal may paſs when melted, is perforated through the bottom of the furnace; correſponding to this hole, which is ſtopped with earth, there is a triangular channel cut in the ſand, to receive the metal. The operation begins with putting into the bottom of the furnace a few pieces of burning wood; coals are laid upon the wood; and upon the wood the ore, with ſome matters to promote its fuſion. The matters employed for this purpoſe are uſually calcareous ſtones, called (in French) *caſtine*, with ſome argillaceous ſtones, under the name of *arbue*, and ſometimes quartz or flints. The ore, the ſtones, and the coal, are alternately put into the ſurface, care

being

being taken to cover over the whole maſs with a layer of coal, which muſt reach to an equal height with the upper opening of the furnace. Thus diſpoſed, the maſs is urged with two large bellows till it melt. When the iron melts, it paſſes through the coals, and is thus reduced to a metallic ſtate. The ſtony matters, as they melt and vitrify, contribute to the fuſion of the iron, which begins at the narroweſt part of the furnace. The melted metal is collected at the bottom of the furnace into a place called the *crucible;* from this it runs through the aperture in the bottom of the furnace into the reſervoir prepared for it in the ſand. It here forms what is called *caſt iron.* A vitreous matter called *ſlag* paſſes after the iron: it is formed by the vitrification of the gangue of the ore with the earths which were added to facilitate the fuſion of the iron. It is of a green, whitiſh, blue, or yellow colour, which is communicated to it by a part of the oxide of the melted iron.

The iron thus obtained is brittle, and without ductility. Metallurgiſts differ in opinion concerning the cauſe of this property of caſt iron: ſome have ſuppoſed it to depend on the metal being intermixed with ſlag. Others have attributed it to the metal not being entirely reduced, but ſtill containing a portion of oxide. Brandt thought it to be arſenic; and M. Sage thinks it is zinc which renders caſt iron brittle. Bucquet conſidered caſt iron as iron imperfectly reduced, and ſtill containing an intermixture of oxide. Bergman, after examining this iron with great induſtry, concluded its fragility to depend on the intermixture of a certain quantity of an extraneous matter, which he thought to be a peculiar metal, and diſtinguiſhed by the name of *ſyderites:*

that matter has been discovered to be a compound of iron with the phosphoric acid. Syderites, as we shall hereafter show, is likewise found in certain irons. The true cause of the fragility, fusibility, granulated texture, and other peculiar properties of cast iron, has been determined beyond a doubt by the ingenious researches of Messrs. Vandermonde, Monge, and Berthollet. They have shown, that cast iron contains both oxigene and coal: the last of which it has absorbed when in fusion in the high furnace. To the various proportions in which it contains these two extraneous bodies, cast iron owes its peculiar properties, and the varieties by which these are diversified.

Metallurgists distinguish various kinds of cast iron; white, grey, black, &c. They give the name of *speckled iron* to that which is variegated with blackish spots on a grey ground. White cast iron is the worst kind; it is almost a semi-metal. The grey is between the first mentioned and the black; which last is esteemed the best, as it affords, the most easily, iron of a good quality. These differences depends on the various proportions in which the oxigene, and still more the coal, is intermixed with the iron. When the proportion of the charcoal is considerable, and it is uniformly intermixed, the cast iron is then black; when the proportion of the charcoal is less, the cast iron is grey. An imperfect mixture, too hastily cooled, gives speckled cast iron. White cast iron contains the smallest proportion possible of charcoal. The nature and the use of cast iron, and the process for converting it into iron, are affected by all of these qualities. The above-mentioned philosophers have discovered, that when cast iron is melted again, there

there is always ſeparated from it a portion of charcoal intimately combined with iron. This compound, which has been hitherto called *plumbago*, forms a cruſt on the ladles in which the caſt iron is taken out to be cooled.

In order to convert caſt iron into iron, it muſt be purified from the coal and the oxigene which it contains. A ſtrong fire, which may penetrate through the whole maſs, is requiſite to effect this reduction. At an high temperature, the charcoal naturally attracts the oxigene, burns, and is diſengaged with efferveſcence, in the form of carbonic acid gas. To accompliſh this, the caſt iron is taken to a refining furnace. It is a forge-furnace, with its hearth ſomewhat hollow; the caſt iron is put into it, and covered over with a good deal of charcoal, The fire is now blown till the caſt iron be melted; when brought into this ſtate, it is repeatedly ſtirred, with the heat ſtill continued. The ſtirring cauſes it to expoſe more ſurface to the heat; and by this means the charcoal ſeizes more of the oxigene, in conſequence of which it is more completely burnt, and diſengaged in carbonic acid gas. The metal appears alſo to detach from itſelf at the ſame time a portion of *ſyderite*, or phoſphate of iron. It is next to be hammered into bars. The hammering, by compreſſing the particles of the metals, contributes to the ſeparation of the carbure and oxide of iron which it ſtill contains; it conſequently effects what could not be effected by the fuſion from its being incomplete. The iron is repeatedly beaten and heated till it be brought to the deſired form and purity. Forged iron is either ſoft or brittle. Soft iron is very ductile; and when broken, which cannot be done without bending it, it

appears to consist of threads and fibres; this has gained it the name of *nervous iron*. But its nervous appearance is accidental; for even the softest iron, if broken smartly at a single blow, does not appear nervous; while the worst iron, if broken with due precautions, may be made to put on this appearance. The grain of this metal affords a better criterion of its quality. The other species of forged iron is more brittle: it has coarse grains, and appears to consist of small scales: This, again, is either brittle when hot, or brittle when cold. The cause of its fragility is now known. That which is so brittle when cold is known to contain much more syderite or phosphate of iron than what is contained in any other sort of iron; still, as iron is more ductile, it is found to contain less syderite; and the softest iron contains none at all. To separate this salt from iron, and to determine its quantity, the metal may be dissolved in sulphuric acid, diluted in water; the solution, when suffered to settle, by degrees deposites the phosphate of iron in a white precipitate, which may be taken up and weighed.

Iron is artificially converted into steel. For this purpose, short bars of iron are inclosed in an earthen box, filled with a cement, which is usually made up of very combustible matters; such as soot from chimnies, or coals of animal matters; sometimes ashes, calcined bones, marine salt, or ammoniac, are added; but these matters are often more hurtful than serviceable. The box is now shut, and exposed to heat for ten or twelve hours, till the bars become pretty white, and begin to soften. In this operation the iron is purified, and completely reduced by means of the combustible matters with which it is closely surrounded. Such parts of it

as were not perfectly in a metallic ſtate, are now enabled to return to that ſtate: and the phoſphate of iron, if any yet remains, appears to be now entirely decompoſed. The iron, being thus ſoftened and dilated, abſorbs part of the ſurrounding charcoal; and cemented ſteel appears, therefore, to be a combination of pure iron completely reduced, with charcoal. It differs from iron, as containing charcoal; and from caſt or crude iron, as not containing, like it, any oxigene together with the charcoal. If caſt iron be deprived of its oxigene, and yet ſuffered to retain its charcoal, it will become ſteel; and again, if you add charcoal to pure iron, without adding to it any oxigene, it will likewiſe be converted into ſteel. Steel is much more fuſible than iron; and therefore bars of iron, converted by cementation into ſteel, are ſoftened to ſuch a degree, that the carbonic acid, which is diſengaged in bubbles, ſwells the ſurface of the metal into ſmall cavities, which are ſufficiently diſcernible. The ſteel which exhibits theſe appearances is called *ben-ſteel* *. The differences of ſteel depend on the iron's having been more or leſs completely reduced, on the quantity of the charcoal contained in it, and on its being ſlowly or quickly cooled; tempering compreſſes its particles more cloſely upon each other, and renders it very hard, dry, and brittle.

It is plain, that what renders all theſe preparations neceſſary, is, becauſe this metal is more difficult to melt than any other, adheres much more obſtinately to the oxigenous principle, and has a ſtronger tendency to combine with it.

There are ores, eſpecially black iron ores, ſuch as

* *Acier poule.*

that of the isle of Elba, in which the metal is so plenteous, and so little altered, that there is no occasion for converting it first into cast iron. It is only softened in a refining furnace, and immediately submitted to the hammer. This is called the *Catalan method.* It cannot be used, except with ores which contain but a small portion of extraneous matters that can run into *slag*.

Sparry iron ores afford iron so pure, and so easily reducible, that they melt very readily, and greedily absorb charcoal as they are reduced. They are on this account called *ores of steel.*

A very intense heat is requisite to melt iron. Iron filings cast into the midst of a pan with burning coals, or even upon the flame of a taper, instantly kindle, and produce very lively sparks; such too are the sparks which issue from a piece of steel when struck against stones. When these sparks are collected upon white paper, they are found to be melted into a kind of dross or scoriæ. This metal, when exposed to the focus of Trudaine's burning-glass, suddenly emits flaming and burning sparks. Macquer, who melted both steel and iron in that lens, observed steel to be the most fusible of the two; which is owing to its being combined with charcoal. When melted iron is slowly cooled, it takes, as we have already observed, a peculiar crystalline form. M. Mongez describes it as a pyramid with three or four sides.

A stream of vital air poured on iron in filings, causes it to burn with as much rapidity as the heat of the focus of the lens in the garden *de l'Infante.* If into a bottle filled with vital air you immerse a piece of iron wire, twisted into a spiral line, with a small bit of lighted

ed tinder at one end, the metal ſuddenly takes fire, and burns with a rapidity and a flame which are very remarkable. As in all theſe inſtances of fuſion the iron becomes brittle, is reduced to oxide, and at the ſame time takes a black colour, iron-ſmiths, and all who have any occaſion to work the metal, conſider it as not being fuſible; and with them it is a maxim that iron is abſolutely infuſible. This opinion, however, proves, when ſtrictly examined, to be erroneous; for when ſubmitted to the action of a very ſtrong fire, without being at the ſame time expoſed to the action of air, iron melts almoſt without alteration. In our accurate experiments, we obtain ſmall buttons of ſoft ductile iron.

Iron, though ſo very hard and refractory, is very eaſily calcined or reduced to oxide. As ſoon as it begins to turn red hot, it combines with oxigene, and burns without any diſcernible flame. A bar of iron, after being kept red-hot for a conſiderable time, exhibits on its ſurface ſcales which may be beaten off with the hammer, (and are called by the French workmen *batitures de fer*). The metal of theſe ſcales is but oxidated in part, for they are ſtill liable to be attracted by the loadſtone. A more perfect oxide of iron may be obtained by expoſing filings of ſteel under a muffle; and this will take place ſtill more readily with ſcales of iron. Theſe are converted into a reddiſh brown powder, not liable to be attracted by the loadſtone, which is called *aſtringent ſaffron of Mars.* We call it *red oxide of iron;* and theſcales we called *black oxide.* The black oxide contains from 20 to 25 parts of oxigene to the hundred; the red oxide contains from 32 to 34 of the ſame principle. The oxides of iron differ according as they ap-

proach nearer to the one or the other of theſe two degrees. Some are of a yellow brown colour; others cheſnut; and others, again, of a moſt beautiful red, like carmine. All of theſe oxides, when mixed with earthy matters, and expoſed to a very ſtrong heat, melt into a blackiſh porous glaſs. They are in part reduced when heated ſlowly in cloſe veſſels. However ſhort the time during which they have been expoſed to the air, they give out, when reduced, a certain quantity of carbonic acid; a circumſtance which proves that they attract this acid from the atmoſphere. This acid is alſo produced from the charcoal which the iron contains, and which becomes acid by abſorbing the oxigene diſengaged from them as they are reduced.

Red oxide of iron is very eaſily reduced with the help of combuſtible matters. On being mixed with a little oil, and heated ſlightly in a crucible, they become black, and very ſubject to the attraction of the loadſtone: But in this operation they loſe not all the oxigene which they contain; they only paſs into the ſtate of black oxide.

The pureſt iron ſoon loſes its metallic luſtre when expoſed to humid air: it is then covered over with a pulverulent brown yellow cruſt. This matter is called *ruſt.* Common iron is much more liable to ruſt, than ſteel. The more the particles of the metal are attenuated and divided, the more rapid is the alteration which it ſuffers from air. On this principle is prepared the medicine known in pharmacy under the name of *aperient ſaffron of Mars.* To produce it, iron filings are expoſed to the air, and watered; and by this means they come to ruſt very ſpeedily. It is formed ſtill more quickly

quickly of iron in the ſtate of *Æthiops*, or black oxide, treated in the ſame manner. In this alteration the metal is agglutinated into maſſes, which are levigated before being employed in medicine. The formation of the ruſt of iron was thought to be owing to the action of the air; but it is now known to be water which calcines the metal in this manner. Some experiments peculiar to myſelf lead me to conſider *aperient ſaffron of Mars* as a combination of oxide of iron with carbonic acid. I have diſtilled *this ſaffron of Mars* in a pneumato-chemical apparatus, and obtained from it a large proportion of this acid. The iron was then changed into a black powder, very ſubject to the attraction of the loadſtone. M. Joſſe, apothecary at Paris, has communicated to the Royal Society of Medicine a ſimilar proceſs for obtaining ſpeedily *martial Æthiops*. He adviſes the making the *aperient ſaffron of Mars* red-hot in a retort, with a balloon perforated with a ſmall hole, fitted, but not luted, to it. By this means the heat diſengages the carbonic acid, which M. Joſſe ſuffers to eſcape through the hole perforated in the balloon; and the iron then remains in the ſtate of black oxide in powder, or *martial Æthiops*. I have by this means often cryſtallized cauſtic potaſh, and ſoda, rubbed over the ſides of the balloon fitted to the retort. In conſequence of the carbonic acid, from the iron, uniting with one or other of the alkalis, the neutral ſalts are formed, to which we have given the name of carbonate of potaſh or of ſoda. I have made many other experiments, and have given an account of them in a particular Memoir, (*Chem. Mem. & Obſerv.* 1784). From all of them I am convinced, that this matter is a true neutral ſalt, formed

by oxide of iron with the carbonic acid. Ruſt ſhould therefore be called *carbonate of iron*, to diſtinguiſh it from the genuine oxides of this metal. This ſalt is preciſely the ſame with what Bergman calls *aerated iron*. This theory, too, has been adopted by Macquer. It explains very naturally how iron comes to contract ruſt ſo ſpeedily in humid and impure air; how it comes to be altered, ſo quickly, and ſo entirely, in places where the air is corrupted by the reſpiration of animals, by combuſtion, or by vapours proceeding from animal matters; as, for inſtance, in ſtables, ſtalls, and houſes of office, &c. Iron is of all metals the moſt liable to alteration from the contact of air, and the alteration is not confined to its ſurface. Very thick bars of iron are often ruſted half way through.

Water acts powerfully on iron when cold. It divides it, and even diſſolves a part of it, according to the experiments of M. Monnet. The purer the iron is, and the more air the water contains, ſo much the more of it does it diſſolve. When iron is for ſome time ſtirred about in water, it appears to be divided into very minute parts; and on decanting the water, which is a little turbid, it depoſites a very fine black powder, which has received the name of *Lemery's martial Æthiops*. This powder muſt be carefully dried by a moderate heat, and in a cloſe veſſel, ſuch as an alembic, leſt the contact of the air ſhould ruſt it. This martial Æthiops is very ſubject to the attraction of the loadſtone; it is a black oxide of iron formed by water. As this operation is very tedious and delicate, various chemiſts have attempted to ſimplify it. Rouelle, in making up this preparation, made uſe of the *mouſſoirs de la Garaye*, and by that means

means obtained a very fine *Æthiops*, in much leſs time than is conſumed in Lemery's proceſs. I believe M. Joſſe's method, which is much more expeditious, might be advantageouſly ſubſtituted in its place. We will hereafter give ſome other proceſſes for preparing *martial Æthiops*. Lemery's is effected by an actual decompoſition of water; hydrogenous gas is diſengaged, and the iron is oxidated by abſorbing twenty-five parts of oxigene to a hundred. We will very ſoon treat more at length of this decompoſition of iron by water.

We have already mentioned, that when ſteel in bars is heated to a certain degree, and ſuddenly immerſed into cold water, it becomes very hard, and very brittle. The hotter the ſteel, and the colder the liqour into which it is immerſed, ſo much the more eminent do theſe qualities become. This operation is called *tempering*. Steel may at pleaſure be cauſed to aſſume any degree of hardneſs. We can alſo deprive it of its *temper*, by heating it to the ſame temperature at which it was tempered, and ſuffering it to cool ſlowly. This effect of water on ſteel appears to depend on the ſudden cooling producing a change in the diſpoſition of its parts, and injuring its cryſtallization. All metals admit of being hardened by tempering; but the more infuſible the metal, ſo much the more eminent the degree in which it acquires this quality. Iron, therefore, is more ſuſceptible of it than any other.

About two years ſince, a much ſtronger action was diſcovered to take place between water and iron. M. Lavoiſier putting iron and water together into bell-glaſs above mercury, obſerved that the iron ruſted, and the water decreaſed in quantity in proportion as an elaſtic

fluid which filled the upper part of the apparatus was disengaged. The fluid disengaged proved to be *inflammable gas*. The iron had gained an additional weight, and was oxidated; M. Lavoisier conjectured, that the water might contain oxigene, and that the inflammable gas, the other principle of the water, might be disengaged, in consequence of the oxigene uniting with the iron. He afterwards made a more decisive experiment, in conjunction with M. Meusnier: in that experiment, water in vapour introduced into a gun-barrel made red-hot, afforded a large proportion of *inflammable gas*: The inner part of the gun was found to have acquired additional bulk, and was become black, brittle, and lamellated, much like the iron ore of the isle of Elba; The metal was found to have gained an increase of weight; and the additional weight which it had acquired, taken together with the weight of the *inflammable gas*, corresponded precisely to that of the water decomposed. The portion of iron oxidated by this means was found separate from that which had not undergone the same alteration. It formed an interior cylinder, thicker than the exterior part; and differing greatly from it in texture, colour, consistency, and form. In order to succeed in this experiment, it is requisite to heat the iron to a white red; for heat contributes greatly to the separation of the principles of the water. And when the gun-barrel is not thoroughly red-hot, and the water not in an highly elastic state when it passes through it, no *inflammable gas* is disengaged, nor is the water decomposed. This has happened with various philosophers; who not making the iron hot enough, and introducing the water into it in a liquid state, have not obtained the same results as

M.

M. Lavoiſier, and have of conſequence denied water to be decompoſable, though Syntheſis concurs to juſtify M. Lavoiſier's inferences from analyſis, as has been incontrovertibly ſhown by the ſame gentleman and M. Mongez. There are many other occaſions on which water is, in a like manner, ſeparated into its conſtituent principles, and gives riſe to many very important phænomena, of which we ſhall hereafter have occaſion to take notice. Such is the experiment by which water was diſcovered to be a compound conſiſting of 0,14 of hydrogene, with 0,86 of oxigene.

Iron does not combine in its metallic ſtate with earthy or ſtony matters; but oxide of iron facilitates the vitrification of all kinds of ſtone; communicating to them a green or brown colour. The colours which oxide of iron communicates to other bodies are various, according as it is more or leſs completely oxidated. This oxide poſſeſſes likewiſe the property of aſſuming and communicating more or leſs conſiſtency to thoſe ſtones with which it is naturally or artificially mixed, and diluted by means of water.

Neither barytes, magneſia, nor lime, acts obſervably upon iron.

The pure fixed alkalis and ammoniac, when diſſolved in water, act in a ſenſible manner on this metal. In the courſe of a few days digeſtion on it, the liquors become foul, and give a precipitate of a ſmall portion of *Æthiops*, or black oxide of iron: And, as has been obſerved by the chemiſts of the Academy of Dijon, a certain quantity of hydrogenous gas is diſengaged during the action of theſe ſubſtances; a circumſtance which proves, that the water contributes to it, as the hydrogenous gas can

be given out only in consequence of its decomposition; to which no doubt the alkalis contribute.

Iron may be dissolved in any of the acids. M. Monnet has observed, that the concentrated sulphuric acid cannot act on this metal, unless it be boiling. On distilling this mixture to dryness, there are found in the retort sublimated flowers of sulphur, and sulphate of iron in a white mass, which may be partly dissolved in water, but which being decomposed by heat, affords no crystals. The sulphuric acid diluted in two parts of water, readily dissolves iron filings cold; at the same time, when the metal is dissolved, a considerable quantity of hydrogenous gas is disengaged. By putting a lighted taper to the mouth of the matrass, after keeping it stopped for some time with the hand, it may be made to detonize with a considerable noise. This gas burns with a reddish flame, sometimes emitting very small sparks, like those of iron filings. Macquer, Bergman, and Mr Kirwan, think that in this instance of combination the sulphuric acid disengages a great part of the phlogiston of the iron, and that the *inflammable gas* belongs solely to this metal. This opinion appears to have been built on the belief, that *inflammable gas* might be extracted from iron alone, without any intermedium, merely by the action of fire. But it is at present a well established fact, that the hydrogenous gas, disengaged from iron by heat, is always in exact proportion to the water it contains; and it is no less certain, that water added to sulphuric acid gives out, in consequence of being decomposed, hydrogenous gas. 1. Because the concentrated sulphuric acid affords only sulphureous gas. 2. Because in this state it cannot act upon iron without the aid of

heat, and even then acts upon it very faintly. 3. Becaufe, whenever water is added, the action becomes more rapid, and hydrogenous gas is produced. 4. Laftly, becaufe concentrated fulphuric acid is in part decompofed by iron when there is no water added; whereas, when water is added to the folution, the acid remains without diminution, and only combines with the oxide of iron. The proof of this laft fact is, that the fame quantity of alkali is required to faturate this acid after it has acted on iron as before. In this operation, therefore, it is the water which oxidates the iron, as was long fince conjectured by M. de la Place; and has been fully proved by Meffrs Lavoifier and Meufnier.

While the fulphuric acid diluted in water acts upon iron, a portion of the metal is precipitated in a black powder, which was taken by Stahl for fulphur, and has been found by M. Monnet to be *martial Æthiops.* That black oxide appears to be more than fufficient for the faturation of the acid. As foon as one part of the iron is combined with one of the acid, although the acid be not nearly faturated, yet the folution ceafes, and it no longer acts upon the metal. M. Monnet, who firft made this obfervation, remarks, that when water is poured into the mixture, the acid begins again to act upon the metal. The caufe of this phænomenon is, that the water which was united with the fulphuric acid has been abforbed by the fulphate of iron, which is already formed, while the acid which remains unfaturated cannot act upon the iron, till by the addition of a new quantity of water more of the metal be reduced to oxide. The fulphuric acid diffolves more than half its own we
iron. This folution, after being filtered and e

affords by cooling a tranſparent ſalt, of a beautiful green colour, in rhombic cryſtals. This is the *martial vitriol*, or *green copperas* of commerce. We call it ſulphate of iron.

People do not take the trouble of making up this ſalt artificially, becauſe nature ſupplies it in abundance, and it is eaſily extracted from *martial pyrites*. All that is requiſite is, to leave thoſe ſulphurs expoſed for ſome time to the air. The moiſture of the atmoſphere contributes to their decompoſition; they become covered with a white efflореſcence, which needs to be diſſolved in water, and cryſtallized, before it can afford ſulphate of iron. This decompoſition of pyrites depends, according to Stahl, on a double affinity. Sulphur is with him a compound of *phlogiſton* and *vitriolic* acid. Neither water or iron, when taken each by itſelf, can decompoſe ſulphur: But when theſe two ſubſtances are made to act upon it together, the iron detaches, and attracts to itſelf the phlogiſton of the ſulphur, and the *vitriolic* acid combines with the water to diſſolve the metal. Such of the pyrites as are leſs diſpoſed to effloreſce, among which are the brilliant pyrites, effloreſce readily after being deprived by roaſting of a part of the ſulphur which they naturally contain. The *vitriol* is ſeparated from it by waſhing. The ſolution of this ſalt depoſites at firſt a certain quantity of iron in the ſtate of ochre. The liquor is not evaporated and cryſtallized till after this depoſitum be precipitated. The modern opinion concerning the effloreſcence of pyrites is, that the ſulphur, which in them is divided as in its combinations with alkaline ſubſtances, combines with a portion of oxigene to form ſulphuric acid, which being diluted by

by the water of the atmoſphere, enters into union with the iron, not without exciting heat, and diſſolves it. What adds a very conſiderable weight to this opinion is, that the contact of air is neceſſary to the efflореſcence of pyrites, and that moiſture, which contributes greatly to their *vitriolization*, acts in this inſtance in the ſame manner as in the ſolution of iron. Such is the origin of the hydrogenous gas, which is diſengaged in this operation when performed *in vacuo*.

Sulphate of iron has a green emerald colour, and a very aſtringent taſte. It ſometimes reddens ſyrup of violets; but it does not uniformly produce this effect. From the experiments of Kunckel and M. Monnet, it appears that theſe cryſtals contain a quantity of water equal to more than half the weight of the ſalt. If this ſalt be ſuddenly expoſed to a pretty ſtrong heat, it becomes liquid, like any of the other ſalts which are more ſoluble in heat than in cold: when dried, its colour is a whitiſh grey. If it be heated at a more intenſe fire, it gives out ſo much of its acid in the form of ſulphureous gas, and becomes red; in this ſtate it is called *colcothar*. Sulphate of iron, when calcined till it becomes red, attracts the moiſture of the atmoſphere, in a very ſenſible manner, by means of the ſulphuric acid which it contains. When diſtilled in a retort, and in a reverberating furnace, this ſalt affords at firſt a water which is faintly acid, and is called *dew of vitriol*. The balloon muſt be changed, when we wiſh to obtain the concentrated ſulphuric acid ſeparately; which, when the heat is very intenſe, appears black as it paſſes into the receiver, and exhales a ſuffocating ſmell of volatile ſulphureous acid. What enables it to diſplay theſe

 phænomena

phænomena is, according to the pneumatic theory, its having loſt a part of its oxigene, which has become fixed in the iron. Towards the end of the operation, the acid diſtilled aſſumes a concrete cryſtalline form, and it is now called *glacial ſulphuric acid.* This experiment, which is deſcribed by Hellot, did not ſucceed with M. Baumé; but among chemiſts in general it is conſidered as certain and infallible. The glacial ſulphuric acid, when diſtilled in a ſmall retort, gives out ſulphureous gas, and becomes white and fluid. It owes its concrete ſtate to the preſence of this gas. It combines with water with hiſſing and heat, and on this occaſion, too, gives out ſulphureous gas. Such is Northauſen's fuming *oil of vitriol*, and the concrete ſalt obtained from it by a moderate heat, of which I have given an analyſis in a Memoir publiſhed among the Memoirs of the Academy for the year 1785.

The reſidue remaining after the diſtillation of ſulphate of iron is red, and reſembles colcothar. When waſhed with water, there is ſeparated from it a white ſalt, but little known, and called *colcothar ſalt*, or *fixed ſalt of vitriol.* What remains is a red inſipid earth, which is pure oxide of iron, and is called *mild earth of vitriol.*

Sulphate of iron, when expoſed to the air, becomes ſomewhat yellow, and is gradually covered with ruſt, by abſorbing oxigene from the atmoſphere, By this abſorption of oxigene, it is gradually more and more calcined, till it become incapable of remaining united with the ſulphuric acid. A ſolution of this ſalt exhibits the ſame phænomenon when brought into contact with the atmoſphere; and either the one or the other may be uſed as an eudiometer.

Cold

Cold water dissolves a quantity of this salt equal to half its own weight; hot water dissolves still more of it: but when sufficiently impregnated, it appears to be rendered turbid by a quantity of ochre more or less considerable. This ochre is separated from it by filtration: and the solution, when cooled, gives out green transparent rhomboidal crystals. The intermediate liquor affords, by evaporation, a new quantity of crystals; and after it is deprived of all that it can afford by crystallization, there remains a blackish brown, or a brown yellow mother water, not susceptible of crystallization. When evaporated by a strong heat, and suffered to cool, this mother water forms a soft unctuous mass, which powerfully attracts the moisture of the atmosphere. When this mass is thoroughly dry, it affords a greenish yellow powder. According to M. Monnet, the mother water of sulphate of iron contains iron in the state of a perfect oxide. He made himself certain of this fact, by forming directly, with the help of heat, a solution of genuine oxide of iron in this acid. The solution is brown, and not susceptible of crystallization.

The oxide of iron may be separated from the mother water, not only by aluminous earth, but also by copper and iron filings, to which perfect sulphate of iron is not liable.—A strongly saturated solution of this perfect salt, if exposed to the air, changes, in a certain space of time, into a mother water of the same nature with the two last-mentioned, by attracting oxigene from the atmosphere.

Sulphate of iron is decomposable by lime and alkalis. Lime-water poured into a solution of this salt produces a precipitate in flakes of a deep olive green colour; a portion

portion of the precipitate is again diſſolved in the water, and communicates to it a reddiſh tinge. In the years 1777 and 1778, I preſented to the Academy two Memoirs on precipitates of iron obtained by cauſtic alkalis, or by alkalis not cauſtic, in which I have accurately deſcribed the phænomena which attend theſe precipitations, and the ſtate of the iron in theſe different circumſtances; I ſhall here give the chief facts which they afford in relation to ſulphate of iron. Cauſtic fixed alkali precipitates the ſulphuric ſolution of iron in dark green flakes, which are again diſſolved in the alkali, formig a kind of martial tincture of a very beautiful red colour. When a ſmaller portion of the alkali is put into the ſolution, the precipitate may be taken up and converted into blackiſh *Æthiops*, or black oxide of iron, by drying it rapidly and in cloſe veſſels. If theſe two precautions were neglected, the iron would very ſoon become oxide, on account of its being moiſt and divided. Potaſh, ſaturated with carbonic acid, or carbonate of potaſh, forms a greeniſh white precipitate, which does not diſſolve again in the alkali. This difference is owing to the carbonic acid, which unites with the iron as faſt as it is ſeparated from the alkali by the ſulphuric acid. Pure or cauſtic ammoniac produces a precipitate from a ſolution of ſulphate of iron in water, of a deep blackiſh green, and which does not diſſolve again in the ſalt. By drying it ſuddenly, and in cloſe veſſels, it may be obtained black, and liable to be attracted by the loadſtone. The precipitate formed by concrete ammoniac, or ammoniacal carbonate, is of a greeniſh grey colour; a part of it is again diſſolved in the ſalt, and communicates to it a red tinge; ſo that the

phænomena

phænomena which ammoniac produces in this ſolution, are in one reſpect directly oppoſite to thoſe of the fixed alkalis: cauſtic fixed alkali diſſolves the precipitated iron very readily; carbonated potaſh, not without the greateſt difficulty.

Aſtringent vegetable matters, ſuch as nut-galls, ſumac, huſks of nuts and pomegranates, quinquina, cypreſs-nuts, logwood, tea, &c. cauſe ſulphate of iron to yield a black precipitate. This precipitate, which cannot be miſtaken for iron, is ſo much attenuated as to remain ſuſpended in the liquor. On adding to this mixture a little gum-arabic, the iron precipitate is permanently ſuſpended, and the compoſition forms the black liquor known under the name of ink. We do not yet certainly know what paſſes on this occaſion. Macquer, M. Monnet, and many other chemiſts, think the precipitate of ink to be combined with ſome principle of the nut-gall which diſengages it from the acid. They appear with ſome reaſon to think that principle in an oily ſtate. M. Guanetti, a phyſician at Turin, has made a number of experiments on iron precipitated by aſtringents from its ſolutions. The reſult of his reſearches, which he has given in his analyſis of the waters of St Vincent, proves that this precipitate is not liable to be attracted by the loadſtone; that it becomes ſo, however, when heated in a very cloſe veſſel; that it is ſoluble in acids without efferveſcence; and that the ſolution no longer receives a black tincture from nut-galls: from which facts it may be inferred, that the iron is combined with the aſtringent principle, and that they exiſt together ſomewhat in the ſtate of a neutral ſalt. In the third Volume of the Elements of Chemiſtry, by the Aca-

demy of Dijon, there is a ſeries of experiments on the aſtringent vegetable principle, which ſeem to repreſent this ſubſtance as of a ſimilar nature with acids. According to thoſe chemiſts, it reddens vegetable blue colours; combines with alkalis; decompoſes ſulphurs; diſſolves, and appears to neutralize metals; decompoſes all ſolutions of metals with peculiar phænomena; aſcends in diſtillation, without loſing its power of acting on metals, and diſplays a vaſt number of other properties which we have not here room to enlarge upon.

The experiments and inductions of the academicians of Dijon have ſince been confirmed by the reſearches of Scheele. That celebrated chemiſt has diſcovered, that the ſimple infuſion of nut-galls in water, ſeparates from it a peculiar acid, ſuſceptible of cryſtallization, which detaches iron from any other acids, and communicates to it a black colour, by bringing it nearer to a metallic ſtate. We call this ſalt the *acid of galls*, or the *gallic acid.* Its hiſtory will occur in the vegetable kingdom.

A phænomenon ſtill more difficult to underſtand than the action of nut-gall on ſulphate of iron, is the decompoſition of this ſalt by an alkali calcined with bullock's blood. By this means we obtain a precipitate of a beautiful blue colour, and inſoluble in acids. This precipitate is called *Berlin*, or *Pruſſian blue*, becauſe it was firſt diſcovered in the city of Berlin. Stahl relates, that a chemiſt, of the name of Dieſbach, happening to borrow from Dippel a quantity of fixed alkali to precipitate a ſolution of cochineal, Dippel gave him alkali on which he had diſtilled his animal oil. The ſalt cauſed Dieſbach's ſolution to yield a blue precipitate. Dippel inquired into the cauſe, and prepared, by a ſimple proceſs, the

the Pruſſian blue, which was made known to the world in the year 1710, in the Miſcellanies of the Academy of Berlin; but the mode of preparation was not communicated. Chemiſts laboured eagerly to diſcover the proceſs for preparing it, and at length ſucceeded. In the year 1724, Woodward publiſhed, in the Philoſophical Tranſactions, a proceſs for preparing this colouring ſubſtance.

To make Pruſſian blue, mix four ounces of nitre, fixed by tartar, with as much dried bullock's blood. Calcine this mixture in a crucible till it be reduced to a coal, and ceaſe to emit flame. Waſh it with as much water as may be requiſite to diſſolve the whole of the ſaline matter, which is called *phlogiſticated alkali*, or *colouring lixivium*; and let this lixivium be concentrated by evaporation. Next diſſolve two ounces of ſulphate of iron, and four ounces of aluminous ſulphate, in a pint of water. Mix this ſolution with the alkaline lixivium; a greeniſh depoſitum is produced, which muſt be ſeparated by the filter and muriatic acid poured upon it. The depoſitum then takes a darker and more beautiful blue colour; and is to be dried by a moderate heat, or in the air.

Many chemiſts have ſince attempted both to prepare and to form a theory of Pruſſian blue. As to its preparation, it is at preſent known, that many other ſubſtances render alkali capable of producing a blue precipitate of iron.

Geoffroy, in the Memoirs of the Academy for the year 1725, ſays, that he found all burnt coals of animal matters capable of communicating this property to alkalis. M. Baumé aſſerts, that *phlogiſticated alkali* may be

pared with the coals of vegetable substances by a stronger heat. Spielman has made it with bitumens; Brandt with soot. The manufactories of Prussian blue are very numerous; and in each of them, it would appear, different methods are employed in the preparations. M. Baunach informs us, that in Germany the hooves, horns, and hides of cattle, are used for this purpose. All animal matters, however, do not appear equally proper for the Prussian lixivium. I have attempted ineffectually to prepare it with the bile in the same manner as with the blood of bullocks. What I obtained was an alkali, which produced in a solution of vitriol a greenish white precipitate; and the precipitate was entirely dissolved in the muriatic acid.

Chemists differ greatly concerning the theory of Prussian blue. Brown and Geoffroy thought it to be the *phlogistic* part of iron extricated by the lixivium of the blood, and united with the aluminous earth. Abbé Menon thought it to be alkali. Macquer, in a Memoir which has deservedly been considered as a master-piece by every chemist, and is inserted among the Memoirs of the Academy for the year 1752, has refuted the opinions of those chemists. He thinks Prussian blue to be nothing but iron, combined with an excess of the inflammable principle which it receives from the *phlogisticated* alkali, and the alkali from the bullock's blood. He observes, 1. That Prussian blue, when exposed to heat, loses its colour, and becomes simply iron again: 2. That this blue is insoluble even by the strongest acids: 3. That alkalis are capable of dissolving the colouring matter of Prussian blue and absorbing it till they be saturated. For this it is sufficient to heat an alkaline

kaline lixivium upon Pruſſian blue till the alkali become unfit to diſcolour it. Alkali, when thus ſaturated with the colouring matter of Pruſſian blue, is found to have loſt moſt of its properties. It is no longer cauſtic; it does not efferveſce with acids; of the earthy ſalts, it decompoſes only ſuch as have barytes for their baſe; it precipitates all metallic ſalts; and this precipitation appears to take place by virtue of a double affinity, the affinity of the acid with the alkali, and the affinity of the metallic oxide with the colouring part of that ſalt. Alkali is thus capable of deſtroying the colour of a twentieth part of its weight of Pruſſian blue; and is then ſaturated with colouring matter. The acids diſengage from it a ſmall quantity of blue ſediment; and the ſulphate of iron is then inſtantly precipitated in perfect Pruſſian blue.

In regard to alkali prepared in the common way, Macquer obſerves, that it is far from being completely ſaturated with colouring matter; and that, from this circumſtance, it produces at firſt a green precipitate from the ſolution of ſulphate of iron. In fact, the portion of the alkali which is ſaturated does give a blue precipitate; but the portion which is not ſaturated precipitates iron in the ſtate of ochre, which gives a green tinge to the blue precipitate, by intermixing the blue with yellow. According to this ingenious theory, the acid poured on the precipitate, ſerves to diſſolve that portion of it which is not in the ſtate of Pruſſian blue, and to improve the colour of that which is. The alum, which is added to the ſolution of ſulphate of iron, ſaturates the alkali which is not already ſaturated with colouring matter; and the earth of this laſt added ſalt,

being precipitated with the Pruſſian blue, brightens its dye. As it is neceſſary to pour acid on the precipitate of ſulphate of iron, in order to brighten Pruſſian blue, that acid may be added to the alkali before it be employed to precipitate the iron; for while the acid ſaturates the pure part of the alkali, it does not combine with that which is impregnated with colouring matter, and is capable of inſtantaneouſly forming fine Pruſſian blue. This *phlogiſticated* alkali may be alſo ſaturated with bullock's blood, by digeſting it over Pruſſian blue till it ceaſe to diſcolour it. Macquer has recommended this alkali, ſaturated with acid, as a good teſt for determining the preſence of iron in mineral waters: but M. Baumé has obſerved, that this liquor itſelf contains a certain quantity of Pruſſian blue, by which it may occaſion miſtakes when applied to this purpoſe. He propoſes, therefore, to digeſt it for ſome time with a little vinegar, by a moderate heat, in order that it may depoſite the blue matter which it contains. Such were the reſults of Macquer's ingenious experiments on Pruſſian blue; but that celebrated chemiſt was himſelf very ſenſible of what was wanting, more eſpecially to explain the nature of the colouring ſubſtance. He could not be perſuaded to conſider that ſubſtance as pure phlogiſton; for he could not conceive how, as is pretended in this hypotheſis, iron, ſuperſaturated with the phlogiſtic principle, could all at once loſe both the property of obeying the attraction of the loadſtone, and that of being ſoluble in acids, which, according to Stahl, this metal owes to its containing phlogiſton. M. de Morveau, in his excellent diſſertation on phlogiſton, has made the firſt attempt to determine the nature of the colouring

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part of Pruſſian blue. He obtained, by diſtilling two drachms of this compound, twenty-two grains of a yellow empyreumatic liquor, which effervefced with alkaline carbonates, and communicated an high red colour to blue paper, but has not been once mentioned by Geoffroy or Macquer, though they likewiſe diſtilled Pruſſian blue.

M. Sage, in the year 1772, ſent to the Electoral Academy of Mayence, a Memoir on *phlogiſticated alkali*, in which he calls it animal ſalt. The lixivium of fixed alkali, treated with blood, and ſaturated by digeſtion on Pruſſian blue, as directed by Macquer, is, according to M. Sage, a neutral ſalt, formed by the animal acid with fixed alkali. It affords, by ſenſible evaporation, cubic cryſtals, either octohædral, or in priſms with four faces, terminating in pyramids having the ſame number of ſides. This ſalt decrepitates on coals: by a violent heat, it melts into a ſemi-tranſparent maſs, ſoluble in water, and proper for making Pruſſian blue. M. Sage thinks, that it is the phoſphoric acid which neutralizes the alkali in this neutral ſalt; becauſe, when the mixture of alkali with bullock's blood is made very hot, it melts, and exhales an acrid vapour, attended with white brilliant ſparks, which, in his opinion, are nothing but phoſphorus in flame: This opinion concerning the nature of the acid of the Pruſſian alkali would be eſtabliſhed as a certain truth, if, on the one hand, it afforded phoſphorus when diſtilled with coal, a phænomenon which in that caſe Pruſſian blue might likewiſe exhibit; and if, on the other hand, Pruſſian blue could be formed by combining phoſphate of potaſh, or ſoda, with a ſolution of iron. But, as M. Sage has given no experiments

experiments to this purpose in his Memoir, his theory cannot be admitted.

The chemists of the Academy of Dijon have, in their Elements, adopted a part of this last doctrine: They consider the *phlogisticated* lixivium as a neutral salt. They recommend crystallizing it by evaporation, in preference to purifying it by vinegar, as has been proposed by M. Baumé. This salt, according to them, is very pure; when cast on nitre in fusion, it causes it to detonize. They say nothing of its decomposition, or the nature of its principles; they call it crystallized Prussian alkali.

Bucquet, on precipitating with muriatic acid, and afterwards filtrating a lixivium prepared for Prussian blue, observed, that the alkali, though apparently pure after this operation, and without any appearance of Prussian blue, yet deposited a blue powder. After filtrating it above twenty times in the space of two years, in order to separate the blue precipitated after each filtration, he at length found the liquor to be no longer capable of forming Prussian blue with the solution of sulphate of iron. I have kept by me for more than eight years, a small portion of this lixivium; during the two last of these years, it has given no precipitate, but has deposited a light bluish coating on the sides of the phial, and has maintained the same colour. I have had occasion to observe this phænomenon twice since I heard Bucquet mention it in his lectures: and I believe it to be invariable. The Duke de Chaulnes showed Macquer a colouring lixivium, which, on being previously mixed with an acid, became incapable of affording Prussian blue. That chemist thinks, that the lixivium which exhibi

this phænomenon must have been prepared in metal vessels. Bucquet concluded from the facts which he is above mentioned to have observed, 1. That the Prussian blue is entirely contained in the alkali employed to precipitate the sulphate of iron; 2. That acids alone are sufficient to separate the alkali: 3. That when this alkali has, in the course of a certain time, deposited all the colouring matter which it contained, it is no longer fit for affording Prussian blue.

The *Journal de Physique*, for the month of April 1778, contains observations on Prussian blue, by M. Baunach, apothecary at Metz, which contribute greatly to support Bucquet's opinion. After describing the process of the German manufactories for preparing Prussian blue, M. Baunach affirms, that the lixivium prepared in those manufactories by the fusion of alkali, and the hoofs, horns, and hides of cattle, causes all metals, and even calcareous earth, to yield a blue precipitate. This alkali, after precipitating metals, dissolves them; and they may be separated by the muriatic acid, when they will display a very beautiful blue colour. The singular facts related in that Memoir, such as the distillation of the Prussian blue produced by this lixivium, which affords neither oil nor ammoniac; the solubility of the blue precipitate formed when muriatic acid is poured on this lixivium in nitric acid; the circumstance of calcareous earth being found in the nitric acid which has destroyed the blue; and the existence of a peculiar phlogisticated earth in it which he could not dissolve; these facts, taken together, seem to suggest, that this blue is not of the same nature with that which is precipitated from [illegible]mmon phlogisticated lixivium,

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which Macquer found to contain iron, and which can be produced only from blood.

Since theſe experiments on Pruſſian blue, Scheele has made a new ſeries of reſearches on the nature of this compoſition, which, together with ſome obſervations of which I have not yet ſpoken, throw much new light on its nature.

1, Common Pruſſian blue, diſtilled by naked fire, affords a very large quantity of hydrogenous gas, together with oil, ammoniacal carbonate, and a little acid phlegm. This gas burns with a blue colour, like that which riſes from marſhes; its ſmell is empyreumatic: lime-water communicates to it the property of burning with a red flame, and detonizing in the air, for it abſorbs from the lime-water part of its carbonic acid. M. de Laſſone has conſidered the gas of Pruſſian blue as a peculiar inflammable gas, . Pruſſian blue, after this analyſis, is in the form of a blackiſh powder, ſubject to the attraction of the loadſtone. M. de Morveau has obſerved, that it becomes orange before taking this colour. He is even of opinion, that Pruſſian blue, converted by heat to orange, might be advantageouſly employed in painting.

2. Ammoniac heated above Pruſſian blue decompoſes it by ſeizing on the colouring matter, and leaving the iron in the ſtate of brown oxide. Macquer made this fact known in the year 1752. Meyer, following him, has given the name of *tinging* liquor to this volatile alkali ſaturated with blue colouring matter, and recommends the uſe of it in analyſing mineral waters. I have obſerved, that when cauſtic ammoniac is diſtilled on Pruſſian blue, the liquor which paſſes does not give a blue colour

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to ſolutions of iron; from which it follows, that the colouring matter is not ſo volatile as ammoniac. When only a part of this ſalt is extracted by diſtillation, the reſidue is of an olive green colour: on diluting it in diſtilled water, and filtrating the liquor, it is found to have impregnated the water with colouring matter; and it accordingly affords a very lively Pruſſian blue with ſulphate of iron.

3. In the year 1780, I diſcovered, that when lime-water is digeſted on Pruſſian blue, it diſſolves the colouring matter, if aſſiſted with a little heat. The combination is very rapid: the lime-water acquires a colour, and the Pruſſian blue takes the appearance of ruſt. This lime-water, when filtrated, is of a fine bright yellow colour; It does not turn ſyrup of violets green; it has not an alkaline taſte, and is not precipitated by the carbonic acid; it does not combine with other acids: in a word, it is neutralized by the Pruſſian colouring matter; and when poured on a ſolution of ſulphate of iron, it affords a fine blue, which does not need to be brightened by an acid. Scheele has mentioned this Pruſſian lime-water, without knowing any thing of my experiments; notwithſtanding of my having given an account of the reſult in my Elements of Chemiſtry, printed in the year 1781. He is of the ſame opinion with me, that this combination is the very beſt that has been propoſed for determining the preſence of iron; becauſe it contains either none, or at leaſt very little, Pruſſian blue completely formed.

5. The cauſtic fixed alkalis inſtantaneouſly deſtroy, in the cold, the colour of Pruſſian blue. I have obſerved that a pretty lively heat is produced on this occaſion; that the alkalis, when pure, diſcolour much more Pruſ-

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ſian blue, than when ſaturated with carbonic acid; and that they afford much more blue with ſolutions of iron, when pure, than when carbonated.

6. I found magneſia likewiſe to poſſeſs the property of diſcolouring Pruſſian blue, but not in ſo eminent a degree as lime.

7. Pruſſian blue in powder, if caſt on nitre in fuſion, produces ſome ſparks; from which we may infer, that it contains a combuſtible matter.

8. Pruſſian blue, prepared without alum, becomes, in a high degree, ſubject to the attraction of the loadſtone, on being ſlightly calcined; but common Pruſſian blue never acquires this property by the action of fire.

9. Pruſſian blue diſcoloured by alkaline matters, and in the ſtate of oxide of iron, regains a part of its blue colour if an acid be poured into it. The cauſe of this phænomenon ſeems to be, that all the colouring matter has not been carried off by the firſt action of the alkalis; and a portion is ſtill retained among the particles of the oxide of iron.

All theſe facts ſhow, that the colouring part of Pruſſian blue acts as a peculiar acid, which ſaturates alkalis, thereby forming neutral ſalts. This is the opinion of a great many chemiſts, particularly of Scheele, whoſe reſearches on this matter I am now to give ſome account of. That celebrated chemiſt has ſhown by his experiments, 1. That the lixivium of blood, or phlogiſticated alkali, is decompoſed by the carbonic acid of the atmoſphere; and that all other acids ſeparate from it the colouring part. 2. That this colouring part is fixed, and retained in the lixivium, by a ſmall quantity of pure iron, or ſulphate of iron. 3. That when it is diſengaged by

by acids, by means of distillation, it fills the balloons with a vapour which makes solutions of iron to yield a blue precipitate. 4. That when Prussian blue, or the lixivium of blood, is distilled entirely, it affords, together with the colouring matter, other products which alter this matter, such as sulphur; and that therefore the colouring matter cannot be obtained pure by this process. 5. That Prussian alkalis, distilled with sulphuric acid, precipitate a good deal of Prussian blue, and afford a liquor impregnated with the colouring matter: the blue precipitated in this operation depends on the iron dissolved in these triple salts, or compounds of alkali, colouring matter and iron. 6. That oxide of mercury, or red precipitate, carries off the colouring matter of Prussian blue by ebullition, in a quantity of water equal to twice the weight of the two substances; and that by distilling this mercurial Prussian lixivium with iron and sulphuric acid, the iron reduces the mercury after the acid has disengaged the colouring part: the colouring matter being dissolved in the water of the receiver as fast as it is disengaged, retains a portion of sulphuric acid; to separate it, Scheele mixes a little chalk with the colour, and distils it by a moderate fire; the colouring matter then passes very pure into the receiver: and as it is disengaged in the state of an elastic fluid, according to what has been observed by M. Monge, it may be received and dissolved in water with the tubes and the apparatus which we have already repeatedly described.

After these experiments on the affinities of the Prussian colouring matter, its obstinate adhesion to alkalis, and the means for obtaining it perfectly pure, Scheele, in a second Memoir, examines into the nature of this sub-

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ſtance, and its combinations with alkalis and metallic oxides. Although his experiments are numerous, and very accurate, Scheele does not prove in this Memoir that the Pruſſian colouring matter is a peculiar acid: On the contrary, he endeavours to ſhow, that it contains inflammable gas, ammoniac, and a carbonaceous principle. He acknowledges, however, that it renders a ſolution of ſoap turbid, and precipitates *hepars*, or alkaline ſulphures; and, in a letter to M. Crell, he calls it the colouring acid. We give this ſubſtance the name of the *Pruſſic acid*, and call its ſaline combinations *Pruſſiates* of potaſh, ſoda, ammoniac, &c. In a note by the tranſlator of Scheele, this acid is ſaid to be decompoſable by the acid of nitre; and a proceſs of M. Weſtrumb's is likewiſe given for obtaining Pruſſiate of potaſh very pure. It conſiſts in ſaturating cauſtic potaſh with colouring matter, digeſting it over white lead, to purify it from any hepatic gas which it may contain, mixing it with diſtilled vinegar, expoſing it to the ſun, as directed by M. Scopoli and Father Bercia, in order to precipitate the iron entirely, and adding to it two parts of rectified alcohol. The Pruſſiate of potaſh is then depoſited in bright lamellated flakes, waſhed with a new quantity of ſpirit of wine, dried, and diſſolved in diſtilled water. Dr Crell ſays, that Scheele ſent him, three months after M. Weſtrumb, an analagous proceſs for obtaining a teſt liquor, the purity of which might be depended upon, to aſcertain the preſence of iron on any occaſion.

The Pruſſic acid, or the colouring matter of Pruſſian blue, has likewiſe engaged M. Berthollet's attention, who has made ſtill later experiments upon it than any of the above-mentioned chemiſts. Though this able philoſopher

pher is not yet fully ſatisfied with his reſearches on this matter, they contain, however, a good many new facts and experiments, of ſuch conſequence as to render it proper for us to give here an extract from his Memoir, which he has obligingly communicated.

M. Berthollet firſt obſerves, that there are two kinds of Pruſſiate of iron; the one common Pruſſian blue, the other Pruſſian blue that has loſt a part of the acid which it poſſeſſes in its ordinary ſtate. The laſt of theſe he calls *Pruſſiate of iron with exceſs of oxide.* Pruſſian blue is in this ſtate, after being diſcoloured by an alkali. To ſeparate this exceſs of oxide, he employs the muriatic acid, which diſſolves it, leaving the Pruſſiate of iron in a neutral ſtate. He obſerves, with M. Landriani, that when alkali is digeſted hot on Pruſſian blue, the alkaline Pruſſiate then formed, diſſolves more oxide of iron than if the digeſtion had been performed with cold. Both of theſe chemiſts are of opinion, that an acid added to this triple combination combines with the exceſs of oxide of iron, and produces a precipitate of Pruſſian blue, juſt as when Pruſſiate of potaſh is mixed with a ſolution of iron. They ſay alſo, that heat cauſes this combination to yield a yellow Pruſſiate of iron, that is, with exceſs of oxide of iron. According to them, the acid added ſeizes the exceſs of oxide of iron, and the Pruſſian blue becoming then leſs ſoluble in the alkaline Pruſſiate, is of conſequence precipitated. When the Pruſſiate of potaſh, prepared by a moderate heat, has depoſited the Pruſſiate of iron with exceſs of oxide of iron, by ebullition, it may then be evaporated to dryneſs, diſſolved again in water and mixed with acids; but will not, by any of theſe expedients, be brought to depoſite Pruſſian blue. M. Ber-

thollet says, that by evaporating the solution of Prussiate of potash thus purified, octahædral crystals are obtained with two pyramids truncated, so as to represent square plates with their edges cut sloping.

This chemist, on mixing a solution of these crystals with sulphuric acid, and exposing the mixture in a phial to the rays of the sun, observed, that in a short time a blue colouring matter began to appear, and was gradually precipitated till the mixture was entirely decomposed. A mixture of the same kind, preserved in a dark place, does not become blue, nor yield a precipitate, even though suffered to stand untouched for a number of months. A strong heat produces absolutely the same effect. From these experiments, M. Berthollet shows how inaccurate the principles on which the processes recommended for purifying alkaline Prussiates were founded. For, says he, instead of purifying them of a portion of Prussian blue, which chemists pretended to be only accidentally mixed in them, they decomposed most part of the matter which they attempted to purify. As Prussiate of potash is a triple salt, the Prussic acid has but a very faint disposition to adhere with potash, and may be separated from it by any other acid. When the extraneous acid combines with the potash, one part of the Prussic acid combines with the oxide of iron, to form Prussian blue, and the other is either volatilized in the the state of acid, or reduced to its principles.

The iron precipitated by alkaline Prussiates retains, according to M. Berthollet, no small portion of those salts; by repeating washing, it may be purified of them: these lixiviums contain alkalis combined with a small portion of Prussic acid; and the Prussiates with excess of alkali

alkali are not ſeparated till after the exceſs of acid contained in the ſolution of iron is carried off by the firſt waſhings; for the latter waſhings precipitate the iron in the ſtate of blue from its ſolutions, which the firſt do not.

The only diſcernible difference which he has found between Pruſſiate of potaſh and Pruſſiate of ſoda is, that the latter cryſtallizes differently from the former. Mineral acids diſengage the Pruſſic acid, which is in part fixed in the Pruſſian blue that is precipitated. This led Scheele to think of another combination, from which he might, with greater facility, obtain this acid pure, on which M. Berthollet has made ſome obſervations. This proceſs, as we have already mentioned, conſiſts in boiling red oxide of mercury with Pruſſian blue and diſtilled water. The Pruſſic acid then forſakes the oxide of iron, to unite with the oxide of mercury, with which it has a ſtronger affinity, and forms a ſoluble ſalt, which cryſtallizes in tetrahædral priſms, terminating in quadrangular pyramids, the ſides of which correſpond to thoſe of the priſms. To this lixivium, after filtrating it, iron and concentrated ſulphuric acid are to be added; the iron unites with the oxigene of the mercury, and afterwards combines with the ſulphuric acid; the mercury is precipitated in a metallic ſtate, as appears from its luſtre. Scheele next diſtilled this mixture by a moderate heat, that he might volatilize only the Pruſſic acid; but he obſerved, that, however moderate the heat which he employed, the Pruſſic was always mixed with a little ſulphuric acid. To prevent this, he added to the mixture a certain quantity of chalk, to fix the ſulphuric acid. Concerning this addition, M. Berthollet has obſerved, that, as Scheele

 has

has not ſpecified the quantity, this operation might very eaſily miſcarry, if the chalk were ever ſo little above what is ſufficient to ſaturate the ſulphuric acid: for calcareous Pruſſiate muſt then be formed, which, by the law of double affinities, would decompoſe the ſulphate of iron.

M. Berthollet has obſerved, that the ſulphuric acid diſengages but a ſmall portion of acid from Pruſſiate of mercury; and that it combines with the greateſt part of that ſalt, without decompoſing it, thus forming a triple ſalt, which cryſtallizes in ſmall needles. According to his experiments, the muriatic acid diſengages more of the acid of Pruſſiate of mercury than the ſulphuric acid does; forming, like it, a triple ſalt cryſtallizable in needles, and much more ſoluble than corroſive mercurial muriate. Alkalis and lime cauſe this triple ſalt to yield a white precipitate. M. Berthollet proves, that alkaline Pruſſiates do not precipitate barytes from its ſolutions, as Bergman thought, but join with the ſolution to form triple ſalts: he ſhows that they precipitate aluminous earth. The precipitate which they form with this ſubſtance ſuffers no alteration from the ſulphuric acid; but when digeſted with ſulphate of iron, it forms Pruſſian blue.

The Pruſſic acid decompoſes the oxigenated muriatic acid, and by obſorbing its oxigene, becomes odorous. In this ſtate it does not ſeem to have any great tendency to unite with alkaline ſubſtances; for they ſcarce render its ſmell weaker. It no longer cauſes ſolutions of iron to yield a blue, but a green precipitate. The contact of the rays of the ſun renders it blue again; iron and ſulphureous acid produce the ſame ef-

fect upon it. The ſame phænomena appear when oxigenated muriatic acid, ſulphate of iron, and Pruſſiate of potaſh, are mixed together. M. Berthollet concludes from this, that Pruſſian blue is liable to no alteration, either from light or from the ſulpureous acid, and that it owes its green colour, ſolubility in acids, &c. to its having abſorbed oxigene.

If the Pruſſic acid be ſuperſaturated with oxigenated muriatic acid, and after that expoſed to the rays of light, it aſſumes new characteriſtic properties. It no longer combines either with oxide of iron, or with water; but is found precipitated to the bottom of either of theſe liquors, in the form of oil, with an aromatic ſmell. If more oxigene be added to it when in this ſtate, and it be now let expoſed to the ſun, it cryſtallizes in ſmall white needles. This acid, thus oxigenated, is reduced to vapours by a moderate heat; theſe vapours are neither ſoluble in water nor combuſtible. M. Berthollet has not yet been able to determine what paſſes in this operation. Is the Pruſſic acid ſimply united with oxigene, without ſuffering any alteration? or is there one of its principles burnt? I am rather inclined to agree with him in adopting the laſt of theſe ideas: For though oxigene appears to adhere but feebly to the Pruſſic acid, yet the Pruſſic acid can no longer be reſtored to its originial ſtate, after being treated in this manner with the oxigenated muriatic acid.

The Pruſſic acid prepared for forming a green precipitate with iron, by means of the oxigenated muriatic acid, forms ammoniac whenever lime or an alkali is mixed with it. Though an acid be poured into this laſt mixture, yet it does not regain the peculiar odour of the

Pruſſic acid; from which M. Berthollet concludes it to have been deſtroyed by the mixture of the alkaline, or calcareous ſubſtance. Although the potaſh employed were perfectly pure, yet an acid poured in after it, produces an effervefcence, and diſengages carbonic acid.

From all theſe experiments, M. Berthollet concludes, that azote, hydrogene, and the pure coaly principle, combined in proportions, and condenſed to a degree ſtill unknown, form what is called the *Pruſſic acid.* The knowledge of this compoſition enables us to underſtand how the Pruſſic acid comes to be formed in animal matters, in certain vegetable ſubſtances, and in ammoniacal muriate contaminated with charcoal. It explains likewiſe the reaſon why this acid is ſo combuſtible, and detonizes with ſuch force with various nitrates, why it affords ammoniacal carbonate by diſtillation, and why the ſame ſalt is formed in it on the addition of oxigenated muriatic acid. M. Berthollet doubts if this ſingular combination contains oxigene. At leaſt, ſays he, if the Pruſſic acid *do* contain oxigene, it contains ſo very little, that the carbonaceous matter is not entirely reduced by it to carbonic acid; for Pruſſian blue affords, by diſtillation, a good deal of carbonated hydrogenous gas.

Such are the facts diſcovered by M. Berthollet. By aſcertaining the nature of the colouring matter of Pruſſian blue, he has proved it not to be a genuine acid, however it may act as an acid in all its combinations. M. Veſtrumb and M. Haſſenfratz have found in Pruſſian blue a little phoſphoric acid. But the laſt of theſe gentlemen ſhows that acid not to be eſſential to its nature.

ture. M. Vaquelin and I have lately discovered, that the Prussic acid is obtained by distilling the urinary calculus, and by treating many vegetable and animal substances with the nitric acid.

Sulphate of iron very easily decomposes nitre. The decomposition is partly owing to the sulphuric acid, which by combining with the alkali of the nitre, expels the nitric acid; but it is likewise owing in a great measure to the re-action of the iron on the last mentioned acid. If the sulphate of iron employed to decompose nitre be scarcely dry, a large quantity of nitrous acid is then obtained, very red and fuming: the residue, on being lixiviated, affords sulphate of potash, fixed alkali, and red oxide of iron, remaining on the filters. But if the sulphate of iron have been well calcined, and the nitre melted, the product obtained will then be very scanty. This product consists of two liquors; one of which being of a dark colour, almost black indeed, swims on the surface of the other, which is red and ponderous, like oil above water. Accordingly, M. Baumé considers this liquor as a kind of oil. There afterwards passes into the neck of the retort a white saline mass, which attracts the moisture of the atmosphere, and is speedily dissolved in water with heat, exhaling at the time a strong smell of spirit of nitre, and very thick red vapours. This solution, when saturated with potash, affords sulphate of potash. The white mass is therefore nothing but sulphuric acid, rendered concrete by a portion of nitrous gas.

There appears to be no difference between the heavy liquor in the balloon, and spirit of nitre obtained in Glauber's way. But the light liquor that swim

on being mixed with ſulphuric acid, produces a lively effervefcence, and even a dangerous exploſion. Almoſt the whole of the nitrous acid is diſſipated, and the ſulphuric acid takes a concrete cryſtalline form. Bucquet, who communicated this diſcovery to the Academy, had at firſt obſerved, that this concrete acid, obtained by diſtillation, exhales red nitrous vapours when diſſolved in water. He inferred, that the ſolidity of the acid muſt be owing to its containing nitrous gas. But to determine this with greater certainty, he attempted to mix the blackiſh brown nitrous acid, which ſwims above the red, with ſulphuric acid highly concentrated. But at the very inſtant of the mixture, ſo rapid a motion took place, that the ſpirit of nitre poured on the ſulphuric acid was expelled with noiſe to a great diſtance; and the perſon who made the mixture was covered all over with ſulphuric acid; and there immediately appeared on his countenance a great many red inflamed pimples, which ſuppurated like the ſmall-pox. The ſulphuric acid became ſoon after concrete, preciſely like that obtained by diſtillation, of which we have given the hiſtory. From this fact, it appears, that this acid may be rendered concrete, as well by nitrous as by ſulphureous gas.

The reſidue remaining after the diſtillation of nitre by ſulphate of iron calcined to redneſs, is nothing but ſcoriæ of iron, from which but very little ſulphate of potaſh can be extracted by waſhing.

The ſolution of ſulphate of iron ſuffers no alteration from hydrogenous gas. But though the baſe of this elaſtic fluid appears to have leſs affinity than iron with oxigene, as has been ſhown in the hiſtory of the decom-

poſition

position of water; yet M. Monnet has obferved, that hepatic gas communicates to fulphuric mother-water the property of affording cryftals: And Dr. Prieftley has reduced brown oxides of iron by the contact of hydrogenous gas. Thefe facts do not contradict our doctrine: they rather confirm it. In fact, iron may be deprived of whatever oxigene it contains above the proportion of 0,28 by the action of hydrogene; but this proportion it obftinately retains, however attacked by that principle. Such is the reafon why, in thefe inftances of reduction, nothing is ever obtained but a black oxide, or martial Æthiops, and why iron oxidated by water is always black.

Alkaline fulphures precipitate fulphate of iron with a blackifh colour. This precipitate is a kind of martial pyrites, or fulphure of iron.

The nitric acid is rapidly decompofed by iron, which difengages from it a good deal of nitrous gas, efpecially if the acid employed be concentrated, and the iron in a ftate of divifion. The metal is fpeedily calcined by the oxigene which it attracts from the acid of nitre; the folution is of a brown red colour; at the end of a certain time it is found to have depofited oxide of iron, efpecially if it have been expofed to the contact of air. On immerfing into it a new quantity of iron, the acid, as has been obferved by Stahl, diffolves it, and the oxide of iron, which it held in folution, is inftantaneoufly precipitated. Yet by employing weak nitric acid and iron in fmall pieces, a more permanent folution may be obtained, in which the metal adheres with more obftinacy to the acid. This laft combination is greenifh, and fometimes of a bright yellow colour. Both thefe

ſolutions, when evaporated, become turbid, and depoſite a brown red martial ochre. But if the latter be highly concentrated, inſtead of affording cryſtals, it takes the conſiſtency of a reddiſh jelly, in part ſoluble in water; the greateſt part, however, being precipitated on ſuch an occaſion. On continuing to heat nitrate of iron, it gives out a good deal of red vapours; and the magma, becoming dry, affords a brick-coloured oxide. This magma, when diſtilled in a retort, affords a ſmall quantity of fuming nitrous acid, a good deal of nitrous gas, and ſome azotic gas. There can be no vital air obtained from it, becauſe the iron retains all the oxigene of the acid. The oxide which remains after the diſtillation of nitrate of iron is of a lively red colour, and would make a fine colouring matter for painters, &c. The nitrous ſolution of iron, however highly ſaturated, has never, on any occaſion, appeared to me liable to be precipitated by diſtilled water. The alkalis decompoſe it with phænomena diverſified according to their different natures. Cauſtic potaſh makes it yield a bright brown precipitate: the mixture aſſumes very ſpeedily a blackiſh brown colour, much deeper than that of the former ſolution. The cauſe of this phænomena is, that a portion, though a very ſmall one indeed, of the precipitate is diſſolved by the alkali. Carbonate of potaſh ſeparates from it a yellowiſh oxide, which very ſoon takes a beautiful orange red colour. If this mixture be ſtirred in proportion as the effervefcence takes place, the precipitate is again diſſolved in much greater abundance than in that which is produced by cauſtic potaſh. M. Monnet has accurately obſerved this phænomenon, and he aſcribes it with good reaſon to the gas, which is diſengaged.

disengaged. This solution of iron by fixed alkali bears the name of *Stahl's alkaline martial tincture*. Its colour is a very beautiful red. M. Baumé advises to prepare it with a nitrous solution of iron, containing but a small portion of the metal. Stahl, again, recommended an highly saturated solution. M. Monnet has observed, that a yellow solution affords a copious precipitate, which is scarce dissolved again in alkali, and does not colour it like martial tincture; whereas a very red solution instantaneously forms a martial tincture with the same alkali. Stahl's martial tincture loses its colour in a certain time, and deposites the oxide of iron which it contains. It may be decomposed with the help of an acid. The acid of nitre separates from it a red brick-coloured oxide, which is soluble in acids, and is called *Stahl's aperient saffron of Mars*. Pure or caustic ammoniac causes the nitric solution of iron to yield an almost blackish deep green precipitate. Ammoniacal carbonate dissolves again the iron which it separates from the acid, and takes a red colour still more lively than that of Stahl's tincture. This solution of iron by ammoniacal carbonate, might be of great use in cases in which there is need both of a powerful tonic and an active discussive.

I have never been able to obtain more than a very small quantity of genuine Prussian blue from the red, saturated, nitric solution of iron, by alkali saturated with the colouring matter of that composition. I could never obtain any thing but a blackish precipitate, liable to be again dissolved by the muriatic acid: the liquor, on this last event, assumed a green colour.

M. Maret, secretary to the Academy of Dijon, has sent to the Royal Society of Medicine, a pro

king *martial Æthiops* very quickly. It confifts in precipitating the nitric folution of iron by cauftic ammoniac, and in wafhing and drying the precipitate without lofs of time. M. d'Arcet, who was employed by the Society to examine M. Maret's procefs, did not uniformly obtain the fame refult. In my Memoirs on Precipitates of Iron, I have determined in what cafes M. Maret's procefs muft fucceed, and when it is likely to fail. To obtain this Æthiops, it is requifite, 1. That the folution of iron have been lately formed, and that very flowly, of weak nitric acid, and iron fomewhat divided, both cold. 2. That the ammoniac be recently prepared, very cauftic, and, above all, have loft, by ftanding undifturbed for fome time, the fmall portion of calcareous earth, and blackifh combuftible matters, which it ufually carries up from the fal ammoniac and lime, if it be not extracted in Woulfe's apparatus. 3. That the precipitate be inftantly feparated from the liquor, and fpeedily dried in clofe veffels. Even when all thefe precautions are carefully taken, the precipitate is fometimes not very black, but rather of a light brown colour. It rifes in fcales, the under furface of which is blackifh; a circumftance which proves, that the contact of air flightly rufts its upper furface. I have obtained a more beautiful and permanent *Æthiops*, by precipitating muriatic and acetous folutions of iron with fixed alkali and cauftic ammoniac; wafhing thefe precipitates fufficiently, and then drying them fpeedily in clofe veffels. Yet I am of opinion, that thefe *Æthiops*, however pure they may be fuppofed to be, ftill retain a fmall portion of their precipitants and firft folvents; as has been obferved by M. Bayen of the precipitates of mercury; and they cannot therefore be employed in medicine

medicine with ſo much certainty as thoſe which I have above mentioned. M. d'Arcet, in his Report to the Royal Society of Medicine concerning M. Maret's proceſs, has communicated a proceſs of M. Crohare's, for making *martial Æthiops*. This apothecary, who is known by a number of judicious chemical operations, prepares *martial Æthiops* by boiling water acidulated with a little nitric acid, upon iron filings. The metal is immediately ſlightly oxidated, and affords a good deal of black oxide, or *martial Æthiops*. But in my opinion, M. Joſſe's proceſs is preferable to all of theſe; it is eaſily performed, and is attended with no danger.

As iron is often uſed in procuring nitrous gas, it cannot be improper to obſerve here, that the nature of this gas is never preciſely the ſame on two occaſions; it varies amazingly, according as the circumſtances of the ſolution are diverſified, as the acid contains more or leſs azote and oxigene, as the iron is more or leſs diſpoſed to abſorb oxigene, as the temperature of the matters is hotter or colder, &c. Gas prepared by this proceſs generally contains more or leſs azote; for as iron abſorbs a greater proportion of oxigene than moſt other bodies, and abſorbs different quantities of it, according as it is more or leſs completely in a metallic ſtate, the effects of nitrous gas diſengaged by this metal are therefore more or leſs uncertain in eudiometric experiments. This truth, which is applicable to all bodies that ſeparate nitrous gas from the acid of nitre, ſhows how little the eſſays of eudiometers with nitrous gas are to be depended upon. Alkaline ſulphures are therefore

fore greatly preferable as tefts for determining the purity of air.

The muriatic acid diluted in water diffolves iron rapidly. A large quantity of hydrogenous gas is difengaged from this folution, the production of which muft be owing to the decompofition of the water, in the fame manner as when the metal is diffolved in the fulphuric acid. The hydrogenous gas produced by the action of iron on the muriatic acid, was formerly thought to be different in nature from that which is difengaged from the fulphuric folution of iron. This elaftic fluid was then thought to be one of the principles of the muriatic acid. But fince the difcovery of the decompofition of water by iron, it has been proved, that the water, and not the muriatic acid, the nature of which is ftill unknown, gives rife to the hydrogenous gas difengaged from the muriatic folution of iron; for the acid remains undiminifhed and unaltered after the exhalation of this gas, and the fame quantity of alkali is neceffary to faturate it which it would have been required before. This folution of iron by the muriatic acid produces a confiderable heat; which continues to be felt till the acid be faturated: a portion of the iron is precipitated in real *Æthiops*, in this as well as in all its other folutions. When filtrated, it is of a green colour, inclining to yellow: It is much more permanent than either of the two former; when inclofed in a phial properly ftopped, it depofites no oxide. I have kept by me fome of it for eight years; in all which time it has depofited nothing but a very light pale yellow duft. But, again, when it is left expofed to the air, it depofites in a few weeks almoft all the iron that it contains;

and the more it has been brought into contact with air, the brighter is the colour of the precipitate. It is at present known as a certain fact, that this precipitation, which is in the same manner produced in all the other solutions of iron, is owing to the metal absorbing the oxigene of the atmosphere; as I conjectured, and suggested to the public in the year 1777. (See my *Memoirs on Chemistry.*)

Stahl announced to the world, that in the combination of iron with the muriatic acid, the muriatic acquired the characteristic properties of the nitric acid. But this fact has not been observed by any other chemist. It appears that Stahl attended only to the yellow colour of this solution, and the smell which it diffuses; a smell in fact but little different from that of spirit of salt, and much the same as that of the oxigenated muriatic acid.

The solution of iron by the muriatic acid does not crystallize regularly when evaporated. M. Monnet has observed, that if left to cool, when its consistency is that of a syrup, it forms a kind of magma, in which flat needled crystals are observed, which are liable to deliquiate. This magma melts by a very moderate heat; when a stronger heat is applied, it is decomposed, but not so easily as nitrate of iron; and when dry, it takes the colour of rust. There is disengaged from it a portion of muriatic acid, which may be obtained by distillation; and which, as has been remarked by Brandt, carries off with it a little oxide of iron.

The Duke d'Ayen, in four excellent Memoirs on the combinations of iron with acids, which he has given the Academy, has entered into a minute examination

of what paſſes when muriate of iron is decompoſed in a retort. He obtained from this operation very ſingular products: He firſt obtained, by a moderate heat, a phlegm ſlightly acidulated: the muriatic acid was then concentrated; and its gas, though much more volatile than water, was in part fixed by the iron. By a much ſtronger heat, a part of the acid was volatilized with a little iron, and ſome cryſtals, not diſpoſed to deliquiate, were formed in the balloon. At the ſame time, there were ſublimed to the upper part of the retort, a number of very tranſparent cryſtals, reſembling razor-blades, which decompoſed the light like the moſt beautiful priſms, diſplaying very beautiful ſhades of red, yellow, green, and blue. There remained at the bottom of the retort a ſtiptic, deliquiating ſalt, of a brilliant colour and a foliated form, preciſely like that ſpecies of talc in large plates, which is improperly called *Muſcovy glaſs*. This laſt ſalt, when expoſed to a violent heat in a ſtone retort, was decompoſed, and afforded a ſublimated product of a ſtill more ſurpriſing nature than any of the former products. It was an opaque matter, truly metallic in its nature, and when examined by the microſcope, it exhibited regular cryſtals, or ſections of hexagonal priſms, which the Duke d'Ayen compares to the ſquare pieces of wood uſed in flooring rooms. Thoſe cryſtals were as brilliant as the beſt poliſhed ſteel, and equally ſubject to the attraction of the loadſtone; this was iron partly reduced and ſublimated *. Art ſeems, in this inſtance, to effect an imitation of

* I have in my cabinet a black iron ore, with ſmall and very brilliant laminæ, half a line in breadth, the form of which nearly reſembles

of nature, which sublimes black oxides of iron by the fire of volcanoes, in the form of bright polished plates like Steel. Such at least appears to be the origin of the specular iron of Mont d'Or and of Volvic; which, according to the accurate observations of M. de l'Arbre, physician at Riom, is always found in the chinks of lavas.

From these particulars, it appears what singular phænomena the science of chemistry offers to our observation, and what valuable discoveries it promises to such as shall pursue a train of experiments with the accuracy and perseverance of the Duke d' Ayen. Let it not escape us, that this reduction of iron favours the doctrine of gases, and that similar products might perhaps be obtained by the same process from many other solutions of metals.

The muriatic solution of iron is decomposed by lime and alkalis, like all martial solutions; but these precipitates are not so much altered, and may be very easily reduced, especially such as are produced by caustic alkalis. I have already observed, that this combination affords by precipitation the purest *Æthiops*, or black oxide of iron, that can possibly be obtained. Alkaline sulphures, sulphurated hydrogenous gas, and astringents, decompose this solution as well as the other two: lastly, Prussian alkalis, or alkaline Prussiates, cause it to yield a very beautiful blue precipitate.

Water

that of the crystals obtained by the Duke d'Ayen. They are very thin small scales, of a very sparkling grey iron-colour, disposed slopewise, so as to intersect each other in all directions, and dispersed in a reddish opaque quartz, or a kind of coarse jasper. This beautiful specimen comes from Lorraine. The iron of Framont is of the same nature. F.

Water impregnated with carbonic acid eafily diffolves iron: all that is neceffary in order to accomplifh this combination is to put iron filings into the acidulated liquid, and to leave the mixture to digeft during a few hours. This liquor, after being filtrated, has a pungent, and fomewhat ftiptic tafte. Meffrs Lane and Rouelle have obferved the carbonic acid to poffefs this property. Bergman calls this combination *aerated iron*, and fays, that when expofed to the open air it acquires a rainbow-coloured pellicle; that it is decompofable by pure alkalis: but that alkalis faturated with carbonic acid produce not the fame effect upon it. This folution gives a green tinge to fyrup of voilets, and affords with calcareous Pruffiate a very brilliant Pruffian blue. When expofed to the air, or heated, it precipitates brown oxide of iron. The name which we give to this combination is *carbonate of iron*. Iron has a ftrong tendency to combine with the carbonic acid. In nature we often find it in this ftate. Muddy iron ores and fparry iron appear to confift moftly of this combination. Ferruginous mineral waters often contain iron in the ftate of carbonate of iron. This falt, when feparated from the water, and dried, is fcarce foluble in that fluid. But it diffolves plentifully in liquid carbonic acid; fubfiding, however, in a precipitate when the acid is volatilized. We know not in what manner the fluoric and the boracic acids act upon iron.

This metal very readily decompofes fulphuric falts, particularly fulphate of potafh or foda. I have treated thefe falts with iron in a crucible, and have found them reduced by fuch treatment to the ftate of fulphures. The lixivium of a fulphure of this kind is of a very deep

green colour. A few drops of acid very ſpeedily deſtroy the colour of this metallic tincture. The greateſt part of the iron, oxidated by the oxigene of the ſulphuric acid, remains undiſſolved in the water of the lixivium; and acids diſengage from it a large quantity of ſulphurated hydrogenous gas.

Iron cauſes nitre to detonize. On throwing into a red-hot crucible a mixture conſiſting of equal parts of iron filings and dry nitre, in a certain time a very rapid motion is excited, and a great many bright ſparks fly out of the crucible. When the detonation is over, the crucible contains a reddiſh oxide of iron, of which a ſmall part is combined with the alkali; when this matter is waſhed, the water diſſolves the alkali, and the oxide of iron remains on the filter. This oxide was formerly called *Zwelfer's ſaffron of Mars.* It is of a reddiſh yellow colour, and is ſcarce ſoluble in acids. The alkali ſeparated from it by waſhing is cauſtic, according to moſt chemiſts; for it is generally thought that metallic oxides act like pure lime on this ſalt, thus ſaturated with carbonic acid *.

Iron eaſily decompoſes ammoniacal muriate. Two drachms of iron filings, triturated with a drachm of this ſalt, give out ammoniac gas. Bucquet, who diſtilled this mixture in a pneumato-chemical apparatus with mercury, obtained from it fifty-four cubic inches of aeriform

 fluid;

* It is to be obſerved, that ſince Black's Theory, concerning the cauſticity of lime and alkalis, has been received, the proper experiments have not yet been made to determine whether metallic oxides and lime, properly ſo called, agree in their phænomena in this reſpect. And, till experiment determine, we can ſay nothing certain on this head. A.

fluid; one half of which was ammoniac gas, and the other half hydrogenous gas. Four ounces of the same filings, with two ounces of ammoniacal muriate, afford, when distilled in a retort with a common receiver, about two drachms of liquid ammoniac, impregnated with a little iron, which it soon deposites in the state of oxide of iron. The residue of these operations is muriate of iron. What occasions the decomposition of ammoniacal muriate by iron is, that the metal eagerly combines with muriatic acid: a proof of which is the disengagement of hydrogenous gas, observed to take place during the operation. In pharmacy, there is a medicine prepared of ammoniacal muriate and iron, which is called *martial flowers of sal ammoniac*, or *ens martis*. A pound of ammoniacal muriate in powder is mixed with an ounce of iron filings: this mixture is exposed in an earthen pot covered with another vessel of the same kind to a fire sufficient to make the under-part of the apparatus red-hot. In five or six hours, there is a yellow matter sublimated, which is to be preserved in a phial; this matter is the *martial flowers*. This substance consists chiefly of sublimated ammoniacal muriate, with a little oxide of iron. As the metal very readily decomposes this salt, only a very small quantity of it must be employed, in order that the greatest part of the salt may be sublimed in its natural state. That portion of the oxide of iron which is volatilized, communicates a yellow colour to the ammoniacal muriate, which is at the same time sublimated.

Oxide of iron decomposes this salt better than the metal itself; for it disengages the ammoniac without heat. That which is obtained by distillation is very fluid, and sufficiently caustic. I have obtained ammoniac,

which gave a slight effervescence with acids, by distilling ammoniacal muriate with half its weight of *aperitive saffron of Mars*, or oxide of iron, prepared with access of air, and of consequence containing carbonic acid. In this instance, the carbonic acid disengaged from the iron combined with the ammoniac, and so rendered it effervescent.

Iron is altered in its colour by hydrogenous gas; but the alteration which it suffers has not been yet sufficiently examined. Black oxide of iron is not decomposed by this gas; but the brown or the red oxides easily are, and they then pass into the state of black oxide; for hydrogene robs them of all the oxigene they contain, more than what is requisite to maintain them in the state of black oxide. Sulphur combines rapidly with iron. A mixture, consisting of iron filings and sulphur in powder, and moistened with a little water, becomes hot in a few hours. It then swells, acquires consistency, absorbs the water, bursts with a discernible crackling, and exhales a good deal of aqueous vapour, accompanied with a fœtid odour, very like that of sulphurated hydrogenous gas. When the mixture is a large mass, it takes fire in the space of four and twenty or thirty hours, and as soon as ever the aqueous vapours cease to arise from it. When the substances have nearly ceased to act on each other, the heat rapidly increases, and inflammation takes place. The smell then becomes much stronger; it seems to be owing to the hydrogenous gas produced by the action of the sulphur and iron on the water. This smell is mixed with another, that of alkaline sulphures and pure hydrogenous gas;

the inflammation obſerved in this experiment is, no doubt, owing to a copious diſengagement of hydrogenous gas; for the flame is more lively than that of ſulphur. It riſes a foot high, according to M. Baumé's account, who obſerved this phænomenon on a mixture, conſiſting of an hundred pounds of iron filings, and as much ſulphur in powder: it laſts only for two or three minutes; the mixture continued red and burning for forty. M. Baumé explains this inflammation into the diſengagement of the phlogiſton of the ſulphur into the ſtate of free fire. Lemery, the father, has given the name of artificial volcano to this experiment. He imagined the fires which kindle in the interior parts of our globe, and by forcing their way to the ſurface, produce earthquakes and volcanoes, to ariſe from a ſimilar combuſtion of pyrites piled on each other, and moiſtened by water. In his opinion, theſe awful phænomena might be imitated, by burying in the earth a mixture of ſulphur in powder and iron filings, reduced to a paſte with water, and covering it over with earth preſſed cloſely down upon it. This experiment did not ſucceed with Bucquet, who repeated it with the greateſt exactneſs. Dr Prieſtley ſeemed to ſhow the reaſon why it failed. That philoſopher obſerved, that the moiſtened mixture of ſulphur and iron abſorbed a certain quantity of air, which might be thought neceſſary to its inflammation. But, notwithſtanding this, the inflammation takes place without the contact of air. It appears, in fact, that the iron being very much divided, re-acts on the fluid, and ſeizes its oxigene, by which it is calcined, and diſengages the hydrogenous gas, which takes an elaſtic form by means of the heat ſeparated from the water. This gas alſo

alſo diſſolves a portion of the ſulphur, and thus becomes ſulphurated hydrogenous gas.

There is a ſtrong analogy between this combination of iron and ſulphur by the humid way, and the effloreſcence of *pyrites*; which, when they are moiſtened by water, produce ſulphurated hydrogenous gas.

Sulphur combines very eaſily with iron by fuſion; the reſult is a ſulphure of iron, or pyrites arranged in needles. As in this caſe the ſulphur increaſes greatly the fuſibility of iron, the metal may be inſtantaneouſly melted with the help of this combuſtible body. In order to this, a ſmall bar of iron, heated to whiteneſs, may be applied to a roll of ſulphur, and the melted matter which runs from them received into water. It will be found in the fluid in brittle blackiſh globules, reſembling *pyrites*, and, like them, in the form of ſmall ſlender concentric pyramids.

Iron with arſenic affords a brittle mixture, which is but very little known.

This metal appears to exiſt in many iron ores; and it is in conſequence of being intermixed with it that iron is brittle when hot.

With cobalt, iron forms a metallic mixture, with ſmall cloſe grains, hard, and not eaſily broken.

It does not appear capable of combining with biſmuth.

In combination with antimony, it forms a brittle alloy with ſmall facets, which yields but very little to the hammer. Iron has more affinity than antimony with ſulphur; and is of conſequence capable of decompoſing ſulphure of antimony. To effect this decompoſition, make five ounces of the points of horſe-ſhoe nails red-

hot in a crucible; throw upon them a pound of pulverized ſulphure of antimony; and apply ſpeedily to this mixture a heat ſufficiently ſtrong to melt it: when it is pretty well melted, add an ounce of nitre in powder, to promote, by a thorough fuſion, the ſeparation of the ſcoriæ from the antimony; let the mixture be now left to cool, and the antimony will be found by itſelf not impregnated with any iron. If the mixture employed conſiſt of one part of iron, with two of ſulphure of antimony, the antimony will be alloyed with iron. The ſcoriæ which are found above antimony alloyed with iron, and prepared with nitre and tartar, are of a yellowiſh colour like amber, which they owe to the iron contained in them, Stahl has, on this account, called them *ſuccinated ſcoriæ.* He directs to reduce them to powder; then boil the powder in water, which carries off the moſt ſubtle part of it; decant off the liquor; filtrate it; and detonize the powder remaining on the filter three times with nitre; then waſh and dry it. and the matter thus prepared is Stahl's *aperitive ſaffron of antimoniated Mars.*

It is ſtill uncertain whether zinc be capable of entering into union with iron. Malouin, in his Memoir on Zinc (*Academy*, 1742), has ſhown, that this ſemi-metal may be applied like tin to the ſurface of a piece of iron, ſo as to ſecure it from the contact of air; a circumſtance which ſhows, that theſe two metallic matters are capable of entering into combination with one another.

It appears that nickel enters into a very intimate union with iron; for, as Bergman has ſhown, theſe two metallic ſubſtances can never be entirely ſeparated.

Mercury can contract no union with iron in its metallic state. Ineffectual attempts have been made to produce a direct combination of these two substances; but their oxides have been combined. Navier has observed, that a snowy white precipitate may be obtained by mixing together a solution of iron and a solution of mercury, both made by the sulphuric acid; and on evaporating this mixture, small flat crystals are formed in it, very thin, and resembling the boracic acid. Navier is convinced that these crystals are a combination of iron with mercury.

Lead cannot enter into union with iron.

It appears that iron and tin may be combined by fusion. That art which consists in coating the surface of iron with tin, or preparing white iron, shows this combination to be possible. The surface of iron to be tinned must be smooth and sparkling. For this end, it is sometimes cleared with an acid, sometimes filed, and sometimes coated with sal ammoniac: when prepared in this manner, it is immersed vertically into a vessel full of melted tin; its position in the vessel is repeatedly changed, in order to bring it more completely in contact with the tin; and when it is thought to be sufficiently tinned, it is taken out and rubbed with saw-dust or bran, to clear it from the tallow or pitch with which the surface of the melted tin is covered, and which of consequence sticks to the surface of the tinned iron. If the iron subjected to this process be in very thin plates, the tin will not barely adhere to its surface, but penetrate through it, and combine with all its parts: and on cutting or breaking it, the same white colour will appear in the midst as on the surface of the plate: From which

it appears, that white iron, properly prepared, is actually a chemical combination. Besides, it is more malleable than iron, and is wrought into vessels of a form which it would be impossible to make the pure metal take with the hammer.

We have seen, in the beginning of this chapter, that iron easily absorbs carbone by heat, forming, by its union with that combustible body, cast iron and steel; with this difference between these two compounds, that in the former oxigene is contained, but not in the latter. In both, the quantity of the iron is much above that of the carbone. Scheele, who has applied chemical analysis to so many happy purposes, found, on investigating by this method the nature of *plumbago*, a species of mineral, the rank and character of which naturalists were long at a loss to determine, that it is nothing but a natural combination, consisting of a large quantity of carbone, with a very small proportion of iron.

Plumbago has been long confounded with *molybdena* *. Pott was the first who proved that neither of these substances contains lead, as they were anciently thought to do. The names bestowed on *molybdena* and *plumbago* were formed to perpetuate the error. They were both indifferently called *lead ore*, *English pencil*, *marine lead*, *black ceruse*, *painter's mica*, *lead pencil*, *false galena*, *talc*, *blende*, *potelot*.

Native *carbure of iron* (a name which, as expressive of the nature of the compound, we have substituted instead of

* It is now agreed, that the substance called *molybdena* is the oxide of a certain acidifiable semi-metal. Its history has been given among the semi-metals. F.

of *plumbago)* is found in mountains, frequently among beds of quartz, feldt-ſpar, clay, or chalk, in the form of irregular round lumps, or balls, like the teſticles of animals of various ſizes; the largeſt weighing from eight to ten or eleven pounds; ſometimes, too, it is ſcattered in much ſmaller fragments; and ſometimes even in ſtrata or layers. The inhabitants of Bleoux, a hamlet near Curban, in the higher part of Provence, work *native carbure of iron*, or plumbago, which is found in ſtrata of the thickneſs of four feet, between two beds of clay; the matter is ſold at Marſeilles. M: de la Peyroux reckons carbure of iron among the minerals of the Pyrenees: it is found in Spain and in Germany; in the duchy of Cumberland in England, there is a very rich mine of it; it is made into pencils, which are much eſteemed. North America, and the Cape of Good Hope, likewiſe afford ſpecimens of this ſubſtance. *Plumbago* has for ſome time been found in octohædral cryſtals.

Carbure of iron is of a gliſtering blackiſh blue colour; it feels greaſy, and its fracture is tuberculous; whereas, *molybdena* has a lamellated fracture. Its being of an unctuous ſoapy nature, has induced ſome chemiſts to conſider it as a kind of impure clay. It ſpots the hands; and the *black pencil* leaves, as every body knows, a blackiſh mark on paper.

Carbure of iron ſuffers no alteration from heat in cloſe veſſels. M. Pelletier, who has made a ſeries of experiments on this ſubſtance, ſince Scheele, without obtaining, however, any different reſult, expoſed 200 grains of it in a well-ſtopped crucible of porcelain, to the heat of the fire uſed in the Sêves manufactory for porcelain; the

the mineral loſt only ten grains: But when heated in contact with air, it burns and is oxidated, ſo as to leave ſcarce any reſidue. Meſſrs Quiſt, Gahn, and Hielm, obſerved, that 100 grains, treated in this manner, in a capſule under a muffle, left only ten grains of ferruginous oxide. This oxidation is a ſlow combuſtion, very difficult to bring about. It does not ſucceed in a common crucible: but to effect it, a thin piece of carbure of iron muſt be expoſed in a broad flat veſſel to the action of a ſtrong fire, and the ſurfaces often cleared, and its poſition changed.

Neither air, water, nor any earthy ſubſtance, acts on carbure of iron. The alkalis act powerfully on this ſubſtance. If one part of carbure of iron, with two of dry cauſtic fixed alkali, or the *lapis cauſticus*, be heated together in a retort with a pneumato-chemical apparatus, the ſmall quantity of water ſtill contained in the ſalt contributes to the combuſtion of this ſubſtance; a product of carbonated hydrogenous gas is obtained; the alkali is found to be ſaturated with carbonic acid; and there remains ſcarce any of the carbure of iron. The reſult of this experiment, and the detonation of carbure of iron with nitre, which will hereafter come under our notice, led Scheele to conſider this matter as a kind of ſulphur formed of *aerial*, or carbonic acid and phlogiſton. We will examine this theory, after having conſidered the other phænomena which this combuſtible body diſplays when expoſed to the action of acids and neutral ſalts.

The ſulphuric acid, according to Scheele, is incapable of acting on carbure of iron. M. Pelletier has obſerved, that when 100 grains of this ſubſtance, and four

ounces of concentrated ſulphuric acid, are digeſted together cold for ſeveral months, the acid acquires a green colour, and becomes liable to congeal by a very moderate degree of cold. This acid, when diſtilled on carbure of iron, paſſes into the ſtate of ſulphureous acid, in conſequence of the combuſtion of a part of that ſubſtance.

The nitric acid produces no alteration upon it. The muriatic acid diſſolves the aluminous earth and the iron, and ſerves to purify it, according to M. Berthollet: M. Pelletier has made uſe of the ſame proceſs in order to obtain pure carbure of iron. With reſpect to the aluminous earth, which the muriatic acid carries off from carbure of iron, Scheele remarks, that the aluminous earth ſeparated in his analyſis, belonged to the crucible in which he had before treated it.

Carbure of iron, when melted with four parts of ſulphate of potaſh, or ſulphate of ſoda, affords alkaline ſulphures, and is entirely decompoſed.

Nitre detonates with the help of this ſubſtance; ten parts of that ſalt are requiſite to burn one of carbure of iron. The fixed alkali which remains after this operation gives a lively efferveſcence with acids, and is found to be mixed with a ſmall quantity of oxide of iron. The ſame effect takes place with nitrate of ſoda and ammoniacal nitrate. M. Pelletier has obſerved, that in this laſt operation there is ammonaic diſengaged in combination with a portion of carbonic acid.

Carbure of iron acts neither on muriate of potaſh nor muriate of ſoda.

When diſtilled with ammoniacal muriate, it gives *martial ammoniacal flowers.* When it is heated with ſulphur

fulphur in a retort, the fulphur is fublimed by itfelf, without producing any alteration on the carbure of iron.

All thefe facts concur to prove, that this fubftance is neither earth nor lead ore, as it was thought to be. But Scheele's Theory, again, who confiders it as a combination of carbonic acid with phlogifton, cannot be admitted, 1. Becaufe that chemift has not informed us what quantity of the acid he obtained; 2. Becaufe he could not compofe *plumbago* artificially, by combining carbonic acid with a combuftible matter. Befides, the two fubftances with which Scheele changed carbure of iron into carbonic acid, effect the change by affording vital air, which combines with the inflammable matter of this fubftance, and gives rife to that acid by the fixation of oxigene; for in this manner does the nitric acid convert tungften, arfenic, and fugar, into acids. With regard to cauftic fixed alkali, which likewife changes carbure of iron into carbonic acid, this effect is plainly owing to the water which that alkali always contains, and which burns the combuftible matter in the fame manner as it confumes zinc and iron; the hydrogenous gas obtained during the re-action of the alkali and the carbure of iron adds confirmation to this theory. It might be ftill farther confirmed by paffing water in vapours upon this fubftance, made red-hot in a copper or porcelain tube, as is done with iron and zinc. Although this experiment has not been yet made, I believe I may venture to advance, that the whole of the carbure of iron would be deftroyed, and converted into carbonic acid, and that the product of the operation would be carbonated hydrogenous gas, mixed with a large

large proportion of carbonic acid. It would then seem a natural inference, that the carbonic acid is a compound of plumbago and oxigene; but as we know from many other experiments, that this acid cannot be found unless when a combination of carbone and oxigene takes place; we must infer, in this instance, that *plumbago* contains a large proportion of carbone, and even consists almost entirely of that combustible body. A few facts concerning the properties of carbone, here thrown together, will farther confirm this assertion.

The carbone or coal of various vegetable matters is brilliant, and has a metallic aspect, like carbure of iron; it soils the hands, and marks paper like that matter; and its texture too is granulated and brittle. The most brilliant coals, such as those of some animal substances, are as difficult to burn as carbure of iron, which needs to be much stirred, exposed to an intense heat, and brought as much as possible into contact with air, in order that it may be consumed; iron is found in both; And lastly, these two substances are both liable to be changed into carbonic acid by combustion. After considering these facts, may we not regard *plumbago* as coal formed in the interior parts of the globe, or buried in the earth? May we not even conclude, that this matter is formed by the combination of some mineral principles? though almost all chemists be of opinion, that nothing but organic matters can be converted into coal. But this notion can be confirmed or refuted only by a regular inquiry into the state of carbure of iron in nature, the circumstances of its formation, and the alteration which it suffers. Since the researches of Messrs Vandermonde, Monge, and Berthollet, into the several states in which iron subsists, discovered

diſcovered theſe facts concerning carbure of iron, they have farther diſcovered, that there is conſtantly formed, on the fuſion of caſt iron, a ſubſtance preciſely ſimilar to native carbure of iron. The ladles with which the caſt iron is taken out to cool are uſually coated with it. Maſſes of it are likewiſe found in cryſtals in repairing the upper parts of the furnaces. We may venture to hope that it will be one day artificially prepared for the ſervice of the arts.

Carbure of iron is a good deal uſed. It is made into pencils; the moſt eſteemed of which come from England. Keſwick, in the county of Cumberland, is the place where that uſed for pencils is found. The native lumps are ſawed into ſmall ſlender pieces; which are put into wooden cylinders with grooves, and cut ſo that the cavity of the cylinder may be entirely filled. The duſt produced from the ſawing and cutting of the pieces inſerted into the cylinders is uſed for pencils of an inferior quality, a great many of which are ſold at Paris. It is mixed with a gum paſte, or melted with ſulphur. Theſe baſe pencils are known in England, either by their melting and burning at the flame of a taper, or by their ſeparating into bits, and even falling into powder when ſteeped in water. The German carbure of iron is likewiſe uſed for pencils: in making them, ſeveral extraneous matters are added; ſuch as coal, ſulphur, &c. In England the fineſt duſt of carbure of iron is uſed for coating the wheel-work of ſome inſtruments; and it facilitates their motions by its greaſy unctuous nature *.

One of the moſt important uſes to which this ſubſtance

* This ſubſtance is likewiſe uſed for blackening the outſides of *coffins*. Its common name is *wood.* H.

stance is applied is to coat iron, in order to preserve it from rusting; the pipes of stoves, the back parts of grates, and other utensils exposed to the action of fire and air, are coated with powder of carbure of iron, which is applied to their surface by simply rubbing with a brush. Homberg, in the year 1699, described a process for giving a leaden colour to utensils of iron. It consists in mixing eight pounds of melted animal fat, with four ounces of camphire, and a sufficient quantity of carbure of iron, and laying this composition on iron so hot that it can scarce be held in the hand: these utensils must be carefully wiped with a cloth, after being covered with this sort of varnish.

The workmen who manufacture lead for hunting-shot, polish and blacken its surface at the same time by rolling it in powder of carbure of iron. It is likewise a part of the composition put upon the pieces of leather used for strapping razors. Lastly, it is used in the manufacture of several black English earthen wares; and in that of the crucibles which are made at Passaw in Saxony.

M. Pelletier, who has given a good account of the various uses to which carbure of iron is applied, found it to answer very well in a luting which he prepared after Pott, with one part of this substance, three of common clay, and a little cow-dung, reduced very small. This luting supports glass retorts well enough: they even melt sometimes without its suffering any change of form.

The principal uses of iron are so extensive, and besides so well known, that it is unnecessary to insist on them here; only we may mention, that no art can do entirely without it, and that it is, as Macquer says, the soul of all the arts. The various modifications of which

it

it is susceptible, render it very suitable for all the purposes to which it is applied. Cast iron is run into utensils more or less solid, and capable of resistance, according to the purposes for which they are designed. The tenacity and hardness of the several species of forged iron render it very suitable for all the purposes to which it is applied. The same is the case with the several kinds of steel. The fineness of the grain and the temper vary so as to divide it into a great many species, each of which is better fitted than any of the rest to some purpose or other in the circle of the arts. Oxides of iron serve for giving a red or brown colour to procelain, pottery, enamels, &c. They are likewise employed in the preparation of artificial precious stones, and mixed with oil for painting colours.

Iron affords a remedy of great use in medicine; to which indeed the art is frequently indebted for success. This is the only metal that has no noxious quality whatever, and of the good effects of which there can be no doubt. There is even, as we have seen, such an analogy between iron and organic matters, that it seems to compose a part of them, and to be often produced by the operation of the vital powers of animals, and by vegetation. The effects of iron on the animal œconomy are various. It stimulates the fibres of the membraneous viscera, and appears to act more especially on those of the muscles, which it affects as a tonic. It fortifies the nerves, and communicates to the animal, when enfeebled and languid, new force and vigour in a remarkable degree. It excites many secretions, especially such as take place by evacuations of blood or urine. It contributes to bring on natural hæmorrhages, such as the menstrual flux and the hæmorrhoids.

It increases and multiplies the contractions of the heart; and of consequence renders the pulse quicker and stronger. It acts with no less energy on the fluids. It passes easily into the channels through which the blood circulates, combines with it, and thus gives it new density, consistency, and colour, and renders it more liable to concretion. It at the same time communicates to it such activity, that it passes without difficulty into the smallest vessels, stimulates of itself the sides of the ducts through which it flows, and thus conveys life and vigour through the whole system. The valuable experiments of M. Menghini, published among the Memoirs of the Institution of Berlin, prove, that the blood of people who make use of iron is higher coloured, and contains more than the natural quantity of this metal. Lorry, who, in the practice of medicine, has displayed that nice acuteness of observation, and that extension of views which distinguish the profound and philosophical physician, observed the urine of a sick person to whom he had administered iron reduced to powder, to take a manifest colour from an infusion of nut-gall. This metal is therefore tonic, strengthening, stomachic, diuretic, alterative, incisive; and in the single operation of this medicine are united the virtues of a great number of drugs. It contracts the fibres like astringents, it increases their oscillation: and it has the superiority over many of the other medicines which possess the same virtues, as being more constant and durable in its effects; for it combines with the organs themselves, by means of the fluids by which these are nourished. It may be usefully administered, therefore, in all cases in which the action of the

 fibres

fibres of the viscera, of the muscles, or even of the nerves, is very feeble; when the stomach and intestines are so languid as to refuse their functions; and in the case of weakness arising from such a cause: in short, whenever the consistency of the fluids is diminished, and they are become too thin, as in the green sickness, and in tendency to dropsy, &c. It is used under many different forms; such as levigated filings, martial Æthiops, astringent and aperitive saffron of Mars, Stahl's alkaline martial tincture, martial flowers of sal ammoniac, &c. To these medicines might perhaps be added iron precipitated from acids, and again dissolved by ammoniac; Prussian blue, the use of which as a medicine, is proposed by the chemists of the Academy of Dijon, &c. Sulphate of iron is applied externally to stop hæmorrhages, &c.

Iron, endowed with magnetic qualities, or artificial loadstone, has been thought to produce some very singular effects on the animal œconomy. According to many modern authors, when laid upon the skin, it eases pain, stops convulsions, occasions redness, sweating, and often, too, the eruption of small pimples; it likewise renders epileptic fits less frequent. We are even assured, that in the space of twelve hours it communicates to water a purgative quality. These assertions, which it is pretended are justified by facts, afford so many proofs to enlightened philosophers of the difficulties with which the study of animal physics is attended. As no body is liable to be affected by the magnetic powers of other bodies which is not itself capable of acquiring such powers, it must therefore be impossible for the loadstone to act by virtue of its magnetic powers upon the animal

œconomy.

œconomy. The phyſicians who aſcribe to it ſuch eminent effects, and ſuch energetic medicinal powers, have been miſled and deceived by the changes, more or leſs ſenſible, which have taken place about the time of the application of the magnetic body, and have been owing to the circumſtances of the caſe, and the happy exertions of nature. This opinion is farther enforced by conſidering, that nature ſeems to act with more irregularity and inconſtancy in removing pains and convulſions, than in any other inſtance; and that the medicinal virtues of the loadſtone are chiefly inferred from the effects which have followed after applying it in caſes of this kind.

To this very elaborate and complete chapter upon *iron*, very few facts can be added.

M. Chaptal ſays, that the cubic foot of iron, weighs not 880 *lib.* as our author alledges, but only 845 *lib.* Its ſpecific gravity is 72,070. Iron ochres, ſuppoſed to be formed by the natural decompoſition of pyrites, are the principal matter employed for dyeing *ſtuffs* with the various ſhades of *brown-red*. They are for this purpoſe calcined. At Maz-Dieu, near Alais in France, a ſtratum of ochre has been found, which affords an inimitable *red*. At Carron in Stirlingſhire, in Scotland, and by Meſſrs Cooper and Barker, between Leith and Edinburgh, many articles of furniture, &c. are very ingeniouſly moulded out of crude iron. H.

CHAP. XIX.

Of Copper.

COPPER is a metal, of a very brilliant red colour, to which the alchemiſts gave the name of *Venus*, on account of the readineſs with which it combines ſo as to ſuffer alteration from a vaſt variety of other bodies. It has a diſagreeable ſmell, which is felt when it is rubbed or heated. Its taſte is ſtiptic and nauſeous, but leſs ſenſible than that of iron. It is hard, very elaſtic, and very ſonorous. Its ductility is conſiderable: it is reducible into very thin plates, and very ſlender threads. In the hydroſtatic balance, it loſes about an eighth or a ninth part of its weight. Such is its tenacity, that a thread of copper, one-tenth of an inch in diameter, ſupports 299 1-4th pounds weight without breaking. Its fracture appears as if it were compoſed of ſmall grains. It is ſuſceptible of a regular form. The Abbé Mongez defines its cryſtals to be quadrangular pyramids, ſometimes ſolid, and ſometimes conſiſting of other ſmaller pyramids, inſerted laterally.

Coppe

Copper is found in various ſtates in the earth. Its ores are very numerous; but they may be all reduced to the following.

1. Native copper of a red colour, malleable, and poſſeſſed of all the other properties of the metal. It is diſtinguiſhed into two ſorts; copper of the firſt formation, and copper of a ſecondary formation, or cementation. The copper of the firſt formation is diſperſed in plates or filaments within a gangue, which is almoſt always of a quartzoſe nature. It is ſometimes found in octahædral cryſtals, one above another, reſembling a kind of vegetation. There are other ſpecimens in maſſes and grains. Copper of cementation is commonly in grains, or in thin laminæ on the ſurfaces of ſtones or iron. That which is found on iron appears to have been depoſited in waters containing ſulphate of copper, and precipitated by iron. Native copper is found in many places over Europe: At St Bel in the neighbourhood of Lyons, at Norberg in Sweden, at Newfol in Hungary, and in ſeveral parts of America *.

2. Copper oxidated and mineralized by the carbonic acid. There are ſeveral varieties of native carbonate of copper.

Varieties.

A. Red copper, or *hepatic copper ore.* This ore is diſtinguiſhed by its dark red colour, like the colour of the ſcales which fall off from copper made red-hot, and then ſtruck with a hammer. M. Monnet conſiders this ore as a natural

* Alſo in different places in England, Scotland, and Wales, at Hamſdorf in Thuringia, &c.

Varieties.

tural oxide of copper: It is generally mixed with native copper and *mountain green:* it is not very plenteous; ſometimes it is found in octahædral cryſtrals, or ſilky fibres called *flowers of copper.*

B. *Earthy copper, mountain green,* or *green chryſocolla.* This ore is a genuine oxide of copper, of a lighter or a deeper green, not heavy, and unequally diſperſed within its gangue. It appears from the analyſis of the malachite, made by the Abbé Fontana, to be combined with carbonic acid. This ore is ſometimes very pure. It may be conſidered as exiſting in three different ſtates.

Simple *mountain green,* earthy or impure, called alſo *green chryſocolla.*

Mountain green in cryſtals, or *ſilky copper* of China. This ore, which is common enough in Voſges and Hartz, is likewiſe found in China. It is pure, and cryſtallized in long ſilky bundles of no ſmall ſolidity.

Mountain green in ſtalactites, or *malachite.* This ſubſtance, which is found in conſiderable abundance in Siberia, conſiſts of layers in the form of nipples, of various ſizes: ſome of the ſpecimens conſiſt of needles converging towards a common centre. The different layers have not all preciſely the ſame ſhade of green. The malachite is hard enough to take a fine poliſh; and various toys are made out of it; but as it is often porous, and full of unequal cavities,

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Varieties.

the ſolid pieces are always the moſt valuable when they come up to a certain ſize.

C. *Mountain blue*, or *blue chryſocolla.* This is an oxide of copper of a deep blue colour; it is ſometimes in a regular form, and in rhomboidal priſmatic cryſtals of a very beautiful blue. It is then called *copper azure.* At other times, it is found in ſmall grains, depoſited in the cavities of different gangues, more eſpecially in quartz. Generally, however, it is in thin layers, in the cavities of grey and yellow copper ores. It appears, that all theſe oxides of copper have been precipitated from ſulphuric ſolutions of this metal by the intermedium of calcareous earths, through which the waters containing them flow. M. Sage conſiders theſe blue copper ores as combinations of copper with ammoniac; and ſays, that they differ from it only in being inſoluble. He likewiſe thinks, that the malachite is nothing but this blue, which he calls tranſparent azure copper ore, with a ſmall alteration. But this opinion is not generally received among the mineralogiſts. M. de Morveau thinks, that the blue differs from the green oxide of copper only in containing a ſmaller proportion of oxigene.

The blue oxide of copper ſeems to be the matter which colours certain ſtones; the turquois ſtone particularly, in which Reamur found copper, appears to owe its colour to this cauſe, as well as the Armenian ſtone, the

Varieties.

baſe of which is calcareous carbonate, or ſulphate of lime. Mr Kirwan makes a ſpecies of copper ore of theſe blue ſtones. The turquois is formed of animal bones, coloured by copper. According to Reamur, the Perſian turquois is not liable to ſuffer from the attacks of the nitric acid. The ſame acid entirely diſſolves the turquois of Languedoc.

3. Copper mineralized by the muriatic acid and combined with clay. M. Werner ſpeaks of this ore in his tranſlation of Cronſtedt. It has been confounded with talc; and a perſon of the name of *Dans* expoſed it to ſale at Paris in the year 1784, under the name of *green mica.* It is in ſmall cryſtals of a beautiful green colour, or in ſmall ſparkling ſcales. Mr Forſter found ſpecimens of this in the mines of Johan Georgenſtadt. The green copper ſand brought from Peru by M. Dombey ſeems to belong to this ſpecies of copper ore: on analyſing it, I have found it to contain a little muriatic acid.

4. Copper mineralized by ſulphur almoſt without iron. It is called *vitreous copper ore;* but the name is very improper. It is dark-grey, violet, brown, greeniſh, or entirely brown and liver-colour. A very moderate heat melts it. It is ponderous, ſometimes flexible, and always of ſuch a conſiſtency, that it may be cut with a knife. In its fracture it appears brilliant like gold. It is one of the richeſt copper ores; for it affords no leſs than 90 pounds of copper in the hundred weight.

5. Copper

5. Copper mineralized by sulphur with more iron than is contained in the species immediately preceding; azure copper ore. It differs from the last only in containing about 30 pounds to the hundred weight: it affords only from 50 to 60 pounds of copper in the hundred weight; the rest is sulphur. These two ores may be assayed by acids.

6. Copper mineralized by sulphur with a good deal of iron; brilliant or yellow golden pyrites. The quantity of the sulphur and the copper varies greatly in this ore; the iron is always in a very considerable proportion. It exists in the earth in veins more or less considerable. This ore is sometimes massy and dark, often scaly, and seemingly micaceous. Such is the form of that of Denmark, Norway, Sweden, and St Marie-aux-Mines. On other occasions, this ore is dispersed in its gangue, as the copper of Alsace; it is then called *speckled copper ore*. This variety is often mixed with a little azure; coppery pyrites exhibit very brilliant colours on their surface, either blue or violet, which are owing to the decomposition of their principles. They are then called *copper with a waving light*, or *peacock-tail copper ores*. They usually contain a great quantity of sulphur, a little iron; and in copper they are not very rich. When these ores are only superficially dispersed on the gangue, they are more particularly distinguished by the name of *copper pyrites*: Of which kind are the ores of Derbyshire in England, some of those of St Bel in the Lyonnois, and a number in the mines of Alsace, as at Caulenbach and Feldens. They are besides found adhering to gangues of all sorts, rock-crystal, quartz, spar, schistus, and mica, &c.

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To assay a copper ore, after being pounded and washed, it must be subjected to long roasting by an intense heat, and melted with four times its own weight of black flux and marine salt. The button thus obtained, which is often blackened with a residue of the sulphur, is next to be melted with four parts of lead, and passed into a cupel, where the silver and gold which it contains may be separated; for there is but very little copper which does not contain some portions of these precious metals. M. Tillet's flux, which is a mixture of two parts of pounded glass, with one of calcined borax, and an eighth of coal, succeeds better in reducing this metal than black flux; for the black flux forms an alkaline sulphure, which dissolves a part of the oxide of copper.

Bergman recommends the sulphuric and the nitric acids for assaying copper ores in the humid way. When the copper has been dissolved by the acids, it is then precipitated by iron.

In working copper ores in the great way, they are first pounded and washed; they are then roasted at the first in the open air, and almost without wood; for when the sulphur which they contain, is once kindled, it burns away of itself. When it ceases to burn, the ore is then roasted anew, and even twice successively on wood, in order to obtain what is called *the mat of copper.* This is the ore after it has lost only a portion of the sulphur which it contained. The fusion to which it is subjected serves to make it expose its surfaces more entirely to the heat; in consequence of which it

is more thoroughly roasted. It is exposed to six or seven successive roastings, according as it contains more or less sulphur, and is then melted into *black copper*. This copper is malleable: still, however, there is so much sulphur united with it, which cannot be separated without extracting at the same time the perfect metals which it contains. The black copper is melted with three times its quantity of lead, which is called *refreshing the copper;* and this mixture is moulded into the form of loaves, which are called loaves of *eliquation*. These are instantly placed on two plates of iron, inclined so as to leave a gutter between them. They terminate immediately over the furnace of eliquation; the under part of which slopes forward. The fire under the plates heats the loaves: the lead melts, and runs under the coals, carrying with it the silver and the gold, with which it has a greater affinity than with copper. After this operation, the cakes are found to be considerably diminished, and to have lost their shape. They are now exposed to a stronger fire; the heat of which is so intense as to melt the copper, so far that it may be entirely separated from the lead. This third operation is called (in French) *ressuage*. The lead, with the perfect metals, is taken to the cupel. As to the copper, it is refined by melting it in a crucible, and suffering it to stand so long melted, that it may throw up, in a scum, any extraneous matters which it contains. It is assayed by dipping into it iron rods, which take up a little copper; and from its being more or less of a bright red colour, a judgment is formed of the purity of the metal. Copper thus refined is run into plates, or divided into *rosettes*. To form a *rosette*, the

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scoriæ with which copper in fusion is covered are carefully taken off. The surface of the metal is suffered to settle and fix: when it ceases to be fluid, it is swept over with a wet besom: The impression of cold contracts it. The portion congealed separates not only from the edges of the crucible, but likewise from the rest of the melted metal, and is taken off with pincers. Most part of the copper in the crucible is thus taken off in *rosettes*. What remains at the bottom is called *the king*.

Cupreous pyrites, containing but little of the metal, are wrought solely for the sulphur and the vitriol. At St Bell, and in many other places, they are roasted and distilled, in order to separate the sulphur. During the roasting, a portion of the sulphuric acid acts on the metal, dissolves it, and thus begins to form a sulphate of copper. The roasted pyrites are next exposed to the air; and when the *vitriolization* is ended, the pyritous efflorescence is lixiviated, the lixivium filtrated and evaporated, in order that it may afford a blue rhomboidal salt in crystals, called *vitriol of copper*, *blue vitriol*, *blue copperas*, or *vitriol of Cyprus*. We shall speak of it when we come to examine the combinations of this metal, under the name of sulphate of copper.

Copper, when exposed to fire, takes nearly the same colours with steel: it becomes first blue, then yellow, and at last violet. It does not melt unless when very red. When fully in fusion, it appears covered over with a green flame: it boils, and is capable of volatilization, as may be observed in the chimnies of founders. There are also found flowers of copper in the crucibles in which it is smelted. Small filings of this metal,

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when thrown into the flames, give them a blue and green colour. It is used in artificial fire-works, on account of this property. If this melted metal be slowly cooled, and the fluid portion decanted off, that which adheres to the sides of the crucible, or roasting pot, employed in the experiment, is found in pyramidal crystals; which are larger and more regular in proportion as the fusion of the metal has been more complete, and its cooling more slowly brought on. The pyramids are quadrangular, and appear to consist of a number of octahædrons dispos'd one over another.

Copper heated in contact with air, burns at the surface, and changes into a blackish red oxide, as it absorbs the base of vital air. This oxide may be easily obtained by making a copper-plate red-hot, and then striking it with a hammer; the oxide comes off in scales. The same thing takes place when a copper-plate is dipped in cold water, after being made red-hot. The sudden contraction of the parts of the metal contributes to the separation of the oxide which covers its surface. The oxide falls to the bottom of the water; it is called *scales of copper*. As the copper is not completely oxidated, it may be burnt anew under the muffle of a cupelling furnace; it then takes a pretty deep brown colour; when urged with a violent heat, it melts into a blackish or brown chesnut-coloured glass. Oxide of copper may be decomposed, and deprived of its oxigene, which destroys its metallic properties, by oils, resins, &c. The scales are in part reducible by themselves; for founders buy them from coppersmiths, and use no means for their reduction but throwing them into large crucibles, above melted copper, with which, as they melt,

melt, they enter into union. The filings of this metal are melted in the same way. Oxide of copper appears to possess some saline properties; but its nature, as a salt, has not yet been the subject of examination.

Air acts upon copper; and the more easily, the more it is loaded with, and altered by moisture. It converts it into a rust, or green oxide, which appears to have some saline properties: it has a taste, and is liable to be acted upon by water: Such was the reason which induced the ancient chemists to consider copper as containing a salt. One thing remarkable with regard to this salt is, that it never penetrates deeper than the surface, and seems to contribute to the preservation of the interior parts of a mass of this metal; as may be inferred from the state of ancient medals and statues, which are well preserved under the coat of rust with which they are covered. Antiquaries call that rust *patina*, and set an high value on it; because it is a proof of the antiquity of those pieces which are covered with it. There are many artists, especially Italians, who know how to imitate this rust on copper; and thus counterfeit ancient pieces of bronze.

The oxidation of copper by humid air, appears to be owing to water in a state of extreme division. This fluid, however, does not appear to attack copper in the same manner as iron at an high temperature. It should rather seem, that cold water oxidates the metal; for it is known to be more dangerous to leave liquors to cool, than to boil them in copper vessels. When the liquor is boiling, and the vessel hot, the aqueous vapour does not attack the surface of the metal; but when the liquor

quor is cold, the drops which adhere to the ſides of the veſſel appear to reduce the copper to a green oxide. This oxidation may be therefore aſcribed, with great probability, to the operation of the air, and the carbonic acid diffuſed through it; for, on diſtilling this ruſt of copper in a pneumato-chemical apparatus, I obtained from it carbonic acid.

Copper does not combine with earthy matters. Its oxide, however, contributes to their fuſion, and combines with them to form brown glaſſes of a lighter or a deeper ſhade.

Barytes, magneſia, and lime, act not in a diſcernible manner on copper: we know not how they act on the oxide of this metal.

Cauſtic fixed alkali, digeſted cold with filings of copper, aſſumes in a certain time, a very light blue ſhade; and the copper is covered over with a duſt of the ſame colour. According to M. Monnet, theſe ſolutions are better effected in cold than in heat. It is, however, of importance to obſerve, that he made the combination with carbonate of potaſh, not with pure fixed alkali. Pure fixed alkali ſeems to have much more influence on copper: But neither of theſe ſalts does any thing more than promote and haſten the precipitation of the oxigene of the atmoſphere into copper; for the oxidation never takes place without the concourſe of air.

This phænomenon is more eſpecially remarkable, when ammoniac is brought into contact with copper; on which occaſion the metal is very ſoon diſſolved. When ammoniac is digeſted on filings of copper, with concourſe of air, it takes, in a few hours, a very beautiful deep blue colour; there is not, however, much of the

the copper diſſolved. I have for a year obſerved the phænomena of this ſolution. I put into a ſmall phial a portion of the cauſtic ammoniac with copper filings; the phial was often unſtopped. At the end of ſome months, I found the ſurface of the metal covered with a blue oxide: its ſides were coated with a pale blue oxide; and the under part of the phial, containing the copper, diſplayed, at the ſurface of the glaſs, a brown oxide, the upper part of which was yellowiſh. When the phial containing this liquor is cloſely ſtopped, the liquor loſes its colour almoſt entirely; but whenever the phial is unſtopped, it appears again. It does not exhibit this phænomenon in an eminent degree, except in the beginning of the operation, and when it is decanted off the copper. If the ſolution be not newly made, and ſtill contain copper, it is of a beautiful blue colour, even in cloſe veſſels; however, when expoſed to the air, its colour becomes ſtill deeper. Theſe phænomena ſhow the influence of the oxigene of the atmoſphere.

When the ſolution of copper by ammoniac is ſlowly evaporated, moſt part of the ſalt is diſſipated; a portion, however, remains fixed with the oxide of the metal, and is depoſited in ſoft cryſtals; as has been obſerved by M. Monnet. M. Sage aſſerts, that very beautiful cryſtals may be obtained from this ſolution by ſlow evaporation; and compares them to natural azure of copper. This laſt ſubſtance, however, affords no ammoniac when heated; is not ſoluble in water; and does not effloreſce in the air, like that which is artificially prepared. M. Baumé ſays, this compound forms very brilliant cryſtals of a very beautiful blue colour. This ſo-

lution, when expofed to the air, becomes very foon dry; and what remains is a matter of a grafs-green colour, which can be nothing but a green oxide of copper. M. Sage thinks this the origin of the malachite: but this oxide does not afford near fo much carbonic acid as the malachite. An acid poured into the folution of copper by liquid ammoniac, produces fcarce any precipitate, but changes the blue colour of the folution into a very light pale green. This phænomenon, which has been obferved by Meffrs Pott and Monnet, fhows, that there is but very little oxide of copper in the ammoniac, and that it is again diffolved by the acid, or by the ammoniacal falt, formed by the addition of the acid. By adding ammoniac to the mixture, however, it may be made to refume its blue colour. Both the oxide of copper reduced to this ftate by fire, and all the other oxides of this metal, are inftantaneoufly diffolved in pure ammoniac; and the falt may be thus impregnated with a confiderable portion of the metal. It takes immediately a very beautiful blue colour; and on this account it has been propofed to ufe it as a teft for afcertaining the prefence or abfence of copper in fubftances in which it may be fufpected to exift.

Ammoniacal oxide of copper, or oxide of copper united with ammoniac, is decompofed into its two conftituents, when expofed to an intenfe heat. The oxigene leaves the copper to unite with the hydrogene of the ammoniac, and to form water; the copper returns to its metallic ftate, and the azote, the other principle of ammoniac, is difengaged in the form of gas. This experiment is one, among others, which led M. Berthollet to difcover the nature of ammoniac. It appears

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alſo, that a little nitre is likewiſe formed at the ſame time by the union of the azote of the ammoniac with a portion of the oxigene of the copper.

Though iron decompoſes the ſolutions of copper, in fact, however, by a different attraction, namely, that of the iron for the oxigene, the ſulphuric acid does not act on copper, except when concentrated and boiling; a good deal of ſulphureous gas is diſengaged while this ſolution takes place. When the ſolution is completed, the two ſubſtances are found to have formed a matter of the conſiſtency of jelly, containing oxide of copper by itſelf, and a portion of that oxide in combination with ſulphuric acid. By lixiviating this matter, and filtrating the lixivium, a blue ſolution is obtained: when evaporated to a certain point, and ſuffered to cool, this ſolution affords oblong rhomboidal cryſtals of a beautiful blue colour, which are ſulphate of copper. If, inſtead of being evaporated, this ſolution be left for a long time expoſed to the air, it affords cryſtals; but it likewiſe precipitates a green oxide,—the colour which all oxides of copper take that are either formed or dried in the air.

Sulphate of copper has a very ſtrong ſtiptic taſte; it is even cauſtic. When expoſed to fire, it melts very quickly: it loſes its water of cryſtallization, and takes a bluiſh white colour. A very ſtrong heat is requiſite to ſeparate the ſulphuric acid, which adheres much more obſtinately to oxide of copper than to oxide of iron. Sulphate of copper is decompoſed by magneſia and lime: the precipitate formed by either of theſe ſubſtances is of a bluiſh white colour: when dried in the air, it becomes green; on this account, chemiſts deſcribe the precipi-

tates of ſulphate of copper as green. The caſe is abſolutely the ſame with thoſe which are obtained by fixed alkalis in different ſtates; they are at firſt bluiſh, and take a green colour when dried: perhaps *mountain green* may be formed in this manner. It is of conſequence to obſerve, that when ſulphate of copper is precipitated by a ſolution of carbonate of potaſh, there is no efferveſcence excited; a circumſtance which proves that the carbonic acid unites very readily with oxide of copper. This phænomenon is not common to all ſolutions of metals. Ammoniac in the ſame manner cauſes ſulphate of copper to yield a bluiſh white ſolution; but the mixture ſoon takes a very deep blue colour; for the ammoniac diſſolves in ſome meaſure the precipitated copper; and a very little of that ſalt is ſufficient to diſſolve again the whole of the copper ſeparated from the ſulphuric acid.

The nitric acid diſſolves copper cold, and with rapidity. A good deal of very high-coloured nitrous gas is diſengaged from this ſolution. This method Dr Prieſtley employed in order to obtain this gas very ſtrong. A portion of the metal, reduced to oxide, is precipitated in a brown powder, and ſeparated from the ſolution by filtration. This ſolution, after being filtrated, appears of a much deeper blue colour than the ſolution of copper by the ſulphuric acid; which ſhows that the copper is here more completely oxidated. This ſolution, carefully evaporated, cryſtallizes by cooling. Macquer, in his Memoir on the ſolubility of ſalts in alcohol, was one of the firſt chemiſts who obſerved this fact. If the cryſtals be very ſlowly formed, they become oblong parallelograms; if depoſited more quickly, hexa-

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hædral prisms, the points of which are obtruse and irregularly formed, and which appear like bundles of divergent needles. Lastly, when this solution is too quickly evaporated, it affords only a magma of no regular form. This, no doubt, is what has made chemists say, that the solution is not susceptible of crystallization. Nitrate of copper is of a very bright blue colour. It is so caustic, that it may be applied to corrode excrescences growing on the skin. It melts, according to M Sage, at a temperature of 77° degrees of Fahrenheit's thermometer. It detonizes on burning coals; but as it contains a good deal of water, the phænomenon is not very discernible. When melted in a crucible, it exhales a good deal of nitrous vapour, which may be collected by distilling it; when dried, its colour is green; when still farther urged with heat, it becomes brown: it is now nothing but pure oxide of copper. I have distilled a quantity of it in a pneumato-chemical apparatus, and it afforded a good deal of nitrous gas, a little carbonic acid, and a little vital air: by this operation it was reduced into the state of brown oxide. Nitrate of copper attracts the moisture of the atmosphere. It may, however, be preserved for a long time in close vessels. When exposed to a hot dry air, it is covered over with a green efflorescence. It is very soluble in water, and rather more soluble in hot than in cold water. The solution, if exposed to the air in flat vessels, or hastily evaporated in dry warm weather, leaves a green oxide, such as the crystals of the salt leave on a similar occasion. Lime makes it yield a pale blue precipitate; fixed alkali, a bluish white precipitate; by ammoniac it yields flakes of the same colour, which are very quickly dissolved,

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and communicate to the liquor a very bright deep blue tincture. Its precipitate by alkaline sulphures is of a brownish red colour, without a fœtid smell; with the tincture of nut-gall, it gives an olive green precipitate. The sulphuric acid likewise decomposes nitrate of copper; and if it be employed in an highly concentrated state, crystals of sulphate of copper are obtained. Stahl first took notice of this decomposition; M. Monnet has since confirmed the fact related by Stahl; and I have several times had occasion to observe it. Iron has been said to have a greater affinity than copper with most of the acids. When a plate of this metal is immersed into a solution of copper in the acids, particularly in the nitric acid, the copper is precipitated in a metallic form, and colours the surface of the iron: but the iron effects this precipitation in consequence of its having a stronger affinity with oxigene than copper has. The copper again, after losing this principle, can no longer remain united with the acid, whilst the iron, after being oxidated, readily continues with it. Sulphate of copper displays the same phænomenon; and jugglers, by this process, make ignorant people believe that they can change iron into copper.

The muriatic acid dissolves copper only when concentrated and boiling; only a very little hydrogenous gas is disengaged when this solution takes place. The muriatic acid takes a very deep green, almost a brown colour. This combination forms a magma, which dissolves readily enough in water; if this magma be lixiviated, the water is of a beautiful green colour; a circumstance which serves to distinguish this from the two preceding solutions. On evaporating it slowly, and suf-

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fering it to cool, it deposites prismatic crystals sufficiently regular, if the evaporation have been cautiously managed; but if the evaporation has been too quick, and the cooling too sudden, they then appear under the form of very small sharp needles. Muriate of copper is of a grass-green colour, very pleasing to behold: its taste is caustic, and very astringent; it melts by a very moderate heat, and when suffered to cool, congeals into a mass. M. Monnet affirms, that the muriatic acid adheres to it with great obstinacy, and that a very considerable heat must be applied to volatilize it: it powerfully attracts the moisture of the atmosphere; it is decomposable by the same intermedia which decompose the preceding salts of copper. I have observed, that ammoniac does not dissolve the oxide which it separates from the muriatic acid, so readily as that which it separates from the sulphuric and the nitric acids. The blue then formed is not so lively, and there remains a portion of the oxide, which the ammoniac does not thoroughly dissolve. Neither the sulphuric nor the nitric acid decomposes muriate of copper. The nitric solutions of mercury and silver decompose it, and are themselves decomposed at the instant of the mixture. A white precipitate is formed in consequence of the muriatic acid uniting with the oxide of mercury or silver; and the oxide of copper combines with the nitric acid. I have however observed, that this liquor does not assume the blue colour which a solution of copper by the acid of nitre ought to have; and that, in general, the oxide of copper formed by the muriatic acid, does not assume this colour but with great difficulty, as we have already seen with regard to ammoniac. I have

found, that in general oxides of copper pafs very eafily from blue to green, and with very great difficulty from green to blue. The muriatic acid diffolves oxide of copper much eafier than copper itfelf. This has been obferved by Brandt. The colour of the folution is a beautiful green; and it cryftallizes as the former: a circumftance which proves, that in faline metallic combinations, the metals are always in the ftate of oxides, as we have already obferved.

Nitre detonizes with difficulty by copper. The falt muft be in fufion, and the copper very hot, in order that the deflagration may take place: ftill, however, it is but very weak. This operation is performed by cafting copper filings on nitre in fufion in a large crucible, in order that their parts may be as much as poffible in contact with each other. When the metal becomes very hot, a flight motion is obferved, with faint fparklings. The refidue is a brownifh grey oxide, mixed with potafh; it is wafhed; the water takes up the alkali, which ftill retains a little copper, and the oxide of the metal remains pure. It melts alone into a deep brown opaque glafs; it is ufed to colour enamels. It is thought that the alkali is rendered cauftic; but more experiments are neceffary to afcertain this.

Copper very readily decompofes ammoniacal muriate. Bucquet, who examined this decompofition with very great care, obtained, on making the experiment in a pneumato-chemical apparatus with mercury, from two drams of copper filings, and a dram of ammoniacal muriate,—fifty-eight inches of elaftic fluid; of which twenty-fix inches were very pure ammoniac, twenty-fix inches detonating inflammable gas, and the remaining fix

six inches a mephitic gas, which extinguished lights, without being absorbed by water, or precipitating lime-water; and was consequently gas azote, produced by the decomposition of a part of the ammoniac. There was a little liquid ammoniac disengaged, of a fine colour, which stood immediately over the mercury. The residue was a blackish green mass, one half of which was dissolved in the water, and communicated to it a fine colour, the distinguishing characteristic of muriate of copper: the other half was a kind of brown oxide of copper, formed by the water of the ammoniacal muriate. On repeating this decomposition on four ounces of copper to two of ammoniacal muriate, with the common apparatus of a balloon, Bucquet obtained two drams and eighteen grains of blue liquid ammoniac, which gave a slight effervescence with acids, and contained about an inch of carbonic acid to the dram. He knew not how to account for the appearance of this last gas: but I suppose it might proceed from some impurities of the sal ammoniac; for on repeating the experiment with ammoniacal muriate, previously purified by sublimation, the ammoniac which I obtained was very caustic, and did not effervesce in the smallest degree with acids. Oxide of copper likewise decomposes ammoniacal muriate, and communicates to the ammoniac which it disengages a portion of carbonic acid, that renders it effervescent. This alkali is always blue, because it takes off with it a small portion of oxide of copper, which colours it. Acids, however, do not precipitate an atom of the metal. There are two medicines prepared in pharmacy with ammoniacal muriate and copper; the former of which has received the name of *cupreous*

to ruſt than pure copper, but at the ſame leſs ductile. The more this metal reſembles gold, the brittler it is: beſides, its nature varies according to the proportion in which the two ſubſtances are mixed together, and the precautions taken in melting them: its varieties are ſimilar, pinchbeck, Prince Rupert's metal, and Manheim gold. 2 By cementing plates of copper with native oxide of zinc, or lapis calaminaris reduced to powder and mixed with coal, and making the crucible in which they are contained red-hot; the copper then forms *yellow braſs*. This laſt compound is not ſo liable to ruſt as copper: it is equally malleable, and more fuſible; but if expoſed for ever ſo ſhort a time to a ſtrong heat, it loſes its zinc, and becomes red copper again.

Copper combines with mercury, but not readily; yet by triturating very thin leaves of copper with mercury, theſe metals may be formed into a ſort of amalgam. A plate of this metal, immerſed into a ſolution of mercury by an acid, takes a fine ſilver colour, owing to the mercury being reduced and precipitated by the copper, which has a greater affinity than mercury with oxigene.

Copper and lead combine very well by fuſion; as appears by the formation of the loaves of eliquation.

It is combined with tin in two ways; either by pouring melted tin on the ſurface of a plate of copper, or by melting the two metals together. The former operation is uſed in tinning copper; the latter forms bronze. Copper veſſels to be tinned, are firſt well ſcoured, to render the ſurface on which the tin is to be applied

plied ſmooth and bright. They are next rubbed with ammoniacal muriate, to make them perfectly clear. They are then made hot, and powdered roſin is caſt upon them. This ſubſtance covers the ſurface of the copper ſo as to prevent it from being oxidated. At laſt the melted tin is poured on, and ſpread over it. Complaints have been made, and with good reaſon, that the tinning of copper veſſels is not ſufficient to defend them from the action of air, of moiſture, and of ſalts; becauſe ſuch veſſels are often obſerved to be covered with verdigris. This might be effectually remedied by laying on a thicker coat of tin, were there not reaſon to fear that when ſuch veſſels are expoſed to any degree of heat above that of boiling water, the tin is then liable to be melted, and thus to expoſe the ſurface of the copper uncovered. To prevent ſuch an accident, the tin may be alloyed with iron, ſilver, or platina, to render it harder and leſs fuſible, in order that it may be laid in thicker layers on the copper. Mixtures of this kind are already made uſe of in ſeveral manufactories. It is amazing how ſmall a quantity of tin is ſufficient to tin copper; for Meſſrs Bayen and Charlard have aſcertained, that a pan nine inches in diameter, and three lines in depth, gained only an additional weight of one and twenty grains by being tinned. This trifling quantity, however, is ſufficient to prevent the danger which might otherwiſe ariſe from the uſe of copper veſſels, when care is taken not to ſuffer ſubſtances capable of diſſolving tin to remain too long in ſuch veſſels, and eſpecially to renew the tinning frequently, as friction, heat, and the action of the ſpoons uſed in ſtirring ſubſtances boiled in them, very ſoon deſtroy the tinning.

ning. There is one thing, however, reſpecting the tin uſed by copperſmiths for tinning pans, which we cannot be too much on our guard againſt. It is often alloyed with one fourth-part of lead; the bad effects of which are to be feared, as lead is well known to be very ſoluble in fats and acids. Government ſhould therefore take meaſures to prevent copperſmiths from being cheated when they purchaſe their tin, and from employing the tin of Malacca or Banca, in any other ſtate but as it comes from the Eaſt Indies, before being melted again, and having its purity debaſed by our tin-workers.

M. de la Folie, a citizen of Rouen, who merits the reſpect of the public for thoſe chemical reſearches which he has proſecuted on matters relative to the arts, and for the uſeful diſcoveries with which he has enriched dyeing, pottery, and many other of the manufactures carried on at Rouen; has propoſed, in order that the inconveniences and dangers attending the uſe of tinned copper may be avoided, to employ, in its ſtead, iron plated with zinc; which, as we have already ſeen, is productive of no dangerous effects. Many people have already adopted the uſe of ſuch veſſels with advantage; and it is to be wiſhed, that they were in general uſe.

Tin melted with copper gives a metal, the ſpecific gravity of which is greater than that of either of the two metals of which it is made up, in conſequence of their mutually penetrating each other in a very intimate manner. The greater the proportion of tin in this mixture, ſo much the more white, brittle, and ſonorous, is the mixture. When very white, it is called *bell-metal:* when

when it contains more than an equal proportion of copper, it is yellow, and bears the name of *bronze*, or *braſs*. It is moulded into ſtatues and into cannons, which muſt be ſo ſolid as not to burſt by a moderate force; and at the ſame time not ſo ductile as to loſe their form by the impulſe of bullets.

Copper and iron may be united by fuſion or by ſoldering. This combination, however, does not very eaſily ſucceed. When a mixture of theſe two metals is melted in a crucible, the iron is found to be often intermixed, but not perfectly united with the copper. Copper decompoſes the mother-water of ſulphate of iron; and yet iron has a greater affinity than acids with copper.

The uſes to which copper is applied are very various, and very well known. A great variety of utenſils are made out of it. Yellow copper, or an alloy of copper with zinc, is principally employed for ſuch purpoſes, on account of its ſuperior ductility and beauty. Copper being a very violent poiſon, ſhould never be adminiſtered as a medicine. The remedies moſt uſually applied in the caſe of poiſoning by copper reduced to oxide or verdigris, are emetics, water drunk in large quantities, alkaline ſulphures, alkalis, &c.

Sulphate of copper contains in the hundred weight 30 *lib.* of acid, 43 *lib.* of water, and 27 *lib.* of copper.

M. Chaptal obtained from a ſolution of copper in the nitric acid, by ſlow ſpontaneous evoporation, *white* rhomboidal cryſtals, which decrepitated upon the coals, emitted by heat, a red gas, and left a grey oxide. H.

CHAP.

CHAP. XX.

Of Silver.

SILVER, called *Luna*, or *Diana*, by the alchemists, is a metal of a white colour, and the most lively brilliancy. It has neither taste nor smell. Its specific gravity is such, that it loses in the hydrostatic balance about one-eleventh part of its weight. A cubic foot of this metal weighs seven hundred and twenty pounds. So great is the ductility of silver, that it may be reduced to leaves as thin as paper, and to threads finer than hairs. A grain of silver may be extended so as to contain an ounce of water. Its tenacity is so considerable, that a wire of silver, one tenth of an inch in diameter, is sufficient to support the weight of two hundred and seventy pounds without breaking. It possesses hardness and elasticity in an inferior degree to that in which copper possesses these qualities; it is, next after copper, the most sonorous of all metals. It becomes hard under the hammer, but may be easily deprived by heating of the hardness which it thus acquires.

Messrs Tillet and Mongez have cryſtallized ſilver. They obtained it in quadrilateral pyramids, ſometimes ſolitary on the edges of the crucible, at other times laterally united in groups.

Silver is found in various ſtates in nature. The following are the ſilver ores moſt ſtrikingly diſtinguiſhed from each other.

1. Native or virgin ſilver. It is known by its luſtre and ductility. It appears under an amazing variety of forms. It is frequently in irregular maſſes, the ſize of which is more or leſs conſiderable. It is ſometimes in capillary threads twiſted round; its formation then appears to be owing to the decompoſition of a red ſilver ore, as has been obſerved by Henckel and M. Romé de Liſle. It is likewiſe found in plates, or in pieces of network reſembling ſpiders webs, which the Spaniards on this account call *arané*; ſometimes again in a vegetable form, or in branches conſiſting of octohædrons riſing one over another. Some of theſe ſpecimens reſemble the fern-leaf, others are ſeparate cubes and octohædrons, with truncated angles; but theſe laſt are rare. Native ſilver is often diſperſed in a quartzoſe gangue; it is ſometimes found in fat earths. It is found in Peru, in Mexico, at Konſberg in Norway, at Johan Georgenſtadt and Ehrenfriederſdorf in Saxony, at St Marie, at Allemont in Dauphiny, &c. This metal is not known to exiſt in nature in the ſtate of oxide.

2. Native ſilver, in union with gold, copper, iron, antimony, or with gold and copper together, or with arſenic and iron together. Theſe various native combinations of ſilver are found at Freyberg in Saxony,

and in the mines of Guadal-Canal in Spain. But it is to be obſerved, that the proportion of the extraneous ſubſtances is very trifling.

3. *Vitreous ſilver ore* conſiſts, according to moſt mineralogiſts, of ſilver and ſulphur. It is of a blackiſh grey colour like lead; it is alſo brown, greeniſh, yellowiſh, &c. and it may be cut with the knife as well as that metal. It is frequently irregularly ſhaped, ſometimes in octohædral cryſtals, the angles of which are truncated. M. Monnet takes notice of a variety, which, inſtead of being diviſible by the knife, falls into powder. This ore affords from ſeventy-two to eighty-four pounds of ſilver in the hundred weight. It melts very eaſily: when expoſed to a heat ſo moderate as not to melt it, the ſulphur is diſſipated, and leaves the virgin ſilver in a vegetative form, or in filaments.

4. *Red ſilver ore* is often of a deep colour, ſometimes tranſparent, and cryſtallized in cubes, with their edges truncated, or in hexahædral priſms, terminating in trihædral pyramids: at Potoſi this is called *roſſi-clera*. The ſilver is combined in it with ſulphur and arſenic. When it is broken, its colour is lighter within, and it appears to conſiſt of ſmall needles or priſms, converging like ſtalactites. If expoſed, with proper management, to a fire ſtrong enough to make it red-hot, the ſilver is reduced, and takes a capillary vegetative form, like native ſilver. It affords from fifty-eight to ſixty-two pounds of ſilver in the hundred weight. This ſpecies is diverſified into varieties, by the properties of colour, form, and gravity, &c. It is generally found in all ſuch plates as contain the other ſilver ores.

5. Silver

5. Silver with arsenic, cobalt, and iron mineralized by sulphur. Bergman says, that in this ore the silver is sometimes above the proportion of $\frac{50}{100}$ This ore is sometimes grey and sparkling, sometimes of a dark and dusky appearance; efflorescences of cobalt are observable upon it. The silver ore called *goose-dung* belongs to this species.

6. The grey silver ore, which differs from the copper ore called *Fablertz* only in containing a larger proportion of this precious metal. It is either in masses or in triangular crystals, with their sides cut sloping. The largest of these crystals are not of a very bright colour; the small, being dispersed over a smooth gangue, are of so lively a lustre as to afford a very pleasing spectacle when light falls upon them. Grey silver affords from two to five marks of silver in the hundred weight. Grey silver is sometimes introduced into organic matters, and moulded into an exact imitation of their form. It is then called *figured silver ore.* Of this kind is that resembling blades of corn, and that which M. Romé de Lille has observed in the form of the cones and scales of the pine-tree. This ore contains silver, copper, iron, arsenic, and sulphur. When the proportion of the iron is very small, it is then called *white silver ore.* This latter ore is not to be confounded with galena containing silver, which is sometimes called by the workmen *silver ore.*

7. Black silver ore, called by the Spaniards *nigrillo*, is, according to Messrs Lehman and Romé de Lille, nothing but red or grey silver ore decomposed, and brought into a kind of middle state between its original state and that of native silver: it is sometimes found to con-

tain native silver. The latter of these two mineralogists has observed, that when solid, spongy, or worm-eaten, it may be considered as produced from the red and vitreous ores, and is then richer than when friable and pitch-coloured; when it may be considered as originating from the alteration of grey or white silver ores. It therefore affords various products. In general, it affords from six or seven to nearly sixty pounds of silver in the hundred weight.

8. *Corneous silver ore*, or the natural combination of silver with muriatic acid, and a little sulphuric acid, is a pearl-grey, a violet-grey, or a yellowish grey; sometimes, though but seldom, it is semi-transparent: it is soft, and may be easily crushed or cut: it melts at the flame of a taper. It is found in cubic crystals, but oftenest in irregular masses. It frequently contains lumps of native silver. It was formerly thought to contain sulphur and arsenic; but mineralogists have now agreed in respect to its nature. Messrs Cronstedt, Lehman, and Sage, Woulfe, Lommer, and Bergman, have found it to contain muriatic acid, which is disengaged by heat. Woulfe has besides ascertained, that it contains sulphuric acid. It is found at Saxony, at St Marie, at Guadal-Canal in Spain, and at Allemont in Dauphiny.

9. *The soft silver ore* of Wallerius, is silver either native or mineralized, and intermixed with more or less coloured earth. Earths containing silver vary in colour from a dirty grey to a deep brown.

10. Lastly, Silver is often found in combination with other metallic matters in ores, the history of which we have already given. Such are mispickel, the grey cobalt

balt ore, kupfernickel, or nickel ore, sulphure of antimony, which often affords the variety called *silver ore in feathers*, *blende*, *galena*, *martial pyrites*, and *white copper ores*: the latter are only grey silver ores. All of these substances, many times, contain so much silver as renders the working them for the sake of this precious metal profitable: But it is easy to see, that they cannot, with any propriety, be described as peculiar silver ores; and deserve only to be mentioned as containing silver.

Silver ores are assayed in various ways, according to the nature of the ore. All that is strictly requisite in assaying such as contain native silver, is to pound and wash them. In order to separate the metal entirely from extraneous substances altering it; after being washed, it may be triturated with running mercury. The mercury dissolves the silver, and being then volatilized by fire, leaves the perfect metal separate. Sulphureous silver ores need to be roasted, and afterwards melted with a greater or a less quantity of flux. The silver obtained by this melting is commonly alloyed with lead, copper, iron, &c. To separate it, and to ascertain exactly what quantity of the precious metal this mixture contains, a process entirely chemical, and founded on the consideration of the properties of the imperfect metals, is employed. As lead is susceptible of vitrification, and acts in the quality of a flux on the imperfect metals, such as iron and copper, but is incapable of affecting silver in the same manner; lead is therefore employed to separate the perfect metal from such imperfect metals as alter it. The greater the proportion of the extraneous matters by which the silver is alter-

ed, ſo much the more lead muſt be made uſe of to ſeparate them. This alloy is put into flat porous veſſels, made of calcined bones and water. Theſe roaſting pots, which are called *cupels*, as being in the form of ſmall cups, are proper for abſorbing the lead-glaſs formed in this operation. The ſilver after this remains pure. In order to determine what quantity of the imperfect metals any maſs of ſilver contains, it is conſidered as conſiſting of twelve parts, which are called *penny-weights;* and each of theſe conſiſts of twenty-four grains. If the maſs of ſilver under examination has loſt in the cupels only the twelfth part of its weight, it is called *ſilver of eleven penny-weights:* if it has loſt but a twenty-fourth part of its weight, it is *ſilver eleven penny-weights and twelve grains fine*, and ſo on. The cupel is found, after this operation, to have acquired a conſiderable addition of weight; it contains vitreous oxide of lead, and of the other imperfect metals, which were in combination with the ſilver, and have been ſeparated by the lead. As the lead almoſt always contains a little ſilver, it muſt be at firſt cupelled by itſelf, in order to aſcertain what quantity of ſilver it contains; from the button of fine ſilver obtained, a deduction muſt be made for the ſmall portion known to be contained in the lead which is employed, and is called a *witneſs*. The cupellation exhibits a phænomenon from which the artiſt underſtands the ſtate of his operation. As the ſilver becomes pure by vitrification, and the ſeparation of the lead, it aſſumes a much more brilliant appearance than that with which the lead is ſtill intermixed. The luſtre by degrees increaſes; and when the whole ſurface of the metal becomes pure and

of a dazzling brightneſs,—at the very inſtant when the whole aſſumes ſuch an appearance. the operation is finiſhed. The ſilver, after being thus cupelled, is entirely purified from the imperfect metals which it before contained: but it may ſtill contain gold; and a new proceſs muſt be employed to ſeparate the two perfect metals. As gold is much leſs liable than ſilver to be altered by a great many menſtrua, the ſilver is diſſolved by the nitric or the muriatic acid, and by ſulphur; and the gold, which is ſcarce liable to be affected by theſe ſolvents, remains pure. This way of ſeparating ſilver from gold is called *parting*. We will ſpeak of the various ways of parting theſe metals, after deſcribing in what manner the ſeveral ſolvents which are uſed for this purpoſe act upon the ſilver, and when we treat of the alloy of ſilver with gold.

The proceſſes, in the great way, for extracting ſilver from its ores, and obtaining it pure, are nearly the ſame with thoſe which we have deſcribed as proper for aſſaying the ores of this metal. There are, in general, three modes of treating ſilver in the great way. The firſt conſiſts in triturating virgin ſilver with mercury: this amalgam is waſhed, to purify it entirely from earth: it is then ſtrained through goat-ſkin, and diſtilled in an iron retort; after which, the ſilver is melted, and run into ingots. This proceſs cannot be applied to ſilver ores containing ſulphur. Theſe muſt be roaſted and mixed with lead, in order to refine the precious metal by cupellation. This is the proceſs to which rich ſilver ores are ſubjected. As to ſuch as are poor, the method employed upon them is different from either of theſe two. They are melted without being previouſly roaſted,

with a certain quantity of pyrites. This is called *crude fusion*, and affords a mat of copper containing silver, which is treated with lead by eliquation. The lead which takes up the silver as it melts, is afterwards scorified in the cupel, and then leaves the perfect metal pure. Cupellation in the great way differs from that which is performed in the small way; for, whereas in the former the scorified lead is blown over the edges of the cupel with bellows, in the assay the vitrified oxide of lead is absorbed by the cupel.

The silver obtained by the processes which we have described, is, in general, much less liable to alteration than any of the other metals of which we have as yet given the history. The contact of light, however long the metal remain exposed to it, produces no change of its properties. Heat melts it, makes it boil, and volatilizes it, but without altering its nature. An heat sufficient to make it become first red, and afterwards white, is requisite to melt it: it is more fusible than copper. After being kept for some time in fusion, it swells, and exhales vapours, which are nothing but silver volatilized. What puts this fact beyond doubt is, that portions of the metal are found in the funnels of chimnies in which it is melted in large quantities. It is confirmed by a fine experiment of the Academicians of Paris; they exposed very pure silver to the focus of M. de Trudaine's lens, and observed the melted metal to diffuse a thick smoke, which being intercepted by a plate of gold, was fixed upon it, and whitened its surface.

Silver, when slowly cooled, is susceptible of a regular form, and crystallizes in quadrangular pyramids.

M.

M. Baumé obferved, that this metal takes, as it cools, a regular form; which appears from its furface being covered over with filaments refembling the threads of a feather. I have remarked, that the button of fine filver obtained by cupellation, often exhibits on its furface fmall fpaces with five or fix fides, arranged like the flags of a pavement. But its cryftallization in tetrahædral pyramids has not been carefully examined by any but Meffrs Tillet and the Abbé Mongez.

It was long imagined, and many chemifts are ftill of opinion, that filver is fecure againft the joint action of heat and air. It is certain that this metal fuffers no apparent alteration when held for fome time in fufion, and in contact with air. Juncker, however, related, that on treating filver for a confiderable time by reverberation, in the way of Ifaac of Holland, he found it to change into a vitreous oxide. This fact has been confirmed by Macquer. He expofed filver twenty times fucceffively in a porcelain crucible, to the heat of the porcelain furnace at Seves, and obtained, by the twentieth fufion, a vitreous matter, of an olive-green colour, which he confidered as a true vitreous oxide of filver. When this metal is heated in the focus of a burning-glafs, its furface is always covered with a white pulverulent matter, and a greenifh incruftation is formed on the body on which it refts. Thefe facts remove every doubt that could be reafonably entertained of the alteration of filver in fuch circumftances. Though much more refractory againft all attempts to reduce it to an oxide than any other metal, yet is it liable to be at length changed into a white oxide, which, when treated

in a very ſtrong fire, takes an olive-green colour. It might perhaps be poſſible to obtain an oxide of ſilver, by reducing the metal to very thin plates or leaves, and heating it for a conſiderable time in a matraſs, in the ſame way as is done with mercury. The electric ſpark appears likewiſe to oxidate ſilver. It is certain, at leaſt, that this metal has but a very faint tendency to combine with the baſe of vital air, and that heat does not contribute to this combination ſo much as in the caſe of any of the other metals; but, on the other hand, deſtroys it by a very ſlight effort; for all the oxides of ſilver may be eaſily reduced without addition; and oxigene muſt therefore be but very imperfectly combined with the metal, ſince it can be detached from it ſo as to form vital air, by the action of light and heat alone.

Silver is liable to no alteration from air; its ſurface, in a long ſpace of time, is a very little ſullied by the action of the atmoſphere. Water acts not upon it: earthly matters do not combine with this metal: Its oxide, if melted with glaſſes, would probably communicate to them an olive-green colour.

Neither the alkalis nor the ſalino-terrene ſubſtances act in a ſenſible degree on ſilver. The ſulphuric acid, when highly concentrated and boiling, and when the metal is preſented in a ſtate of extreme diviſion, diſſolves it. A conſiderable quantity of ſulphureous acid gas is diſengaged from this ſolution; and the ſilver is reduced to a white matter, on which a new quantity of ſulphuric acid muſt be poured, in order to diſſolve it. By evaporating this liquor, ſulphate of ſilver is obtained in ſmall needles. I have ſeveral times obtained this

ſalt

falt in plates, formed by the longitudinal junction of a number of thefe needles. This falt melts when expofed to fire, and is of a very fixed nature. It is decompofable by alkalis, iron, copper, zinc, mercury, &c. All the precipitates obtained by alkalis may be reduced, without addition, to fine filver, in clofe veffels.

The nitric acid oxidates and diffolves filver rapidly, even without the help of heat. This folution even takes place at times fo quickly, that to prevent the inconveniences arifing from this circumftance, it is found expedient to have the filver in lumps when expofed to the acid. A confiderable quantity of nitrous gas is difengaged on the occafion, and a white precipitate is produced, more or lefs in quantity, if the acid of nitre have been mixed with any portion of fulphuric or muriatic acid. The nitric acid ufually gives it a blue or a green colour. If the filver be pure, it lofes that colour, and becomes tranfparent as foon as the folution is fully accomplifhed: but if the filver happen to contain copper, the folution retains a lighter or deeper greenifh fhade. The pureft filver that can be obtained often contains gold. In this cafe, as the nitric acid is fcarce capable of acting on that metal, when it acts on the filver it feparates fmall blackifh flakes, which fall to the bottom of the veffel, and prove to be gold. It is in confequence of the nitric acid acting in fo different a manner on thefe two metals, that it is happily employed to feparate them in the operation of parting by aquafortis. The nitric acid diffolves a quantity of filver equal to half its own weight. This folution is exceedingly cauftic; fo much fo, that it produces black fpots on the epidermis, and eats entirely through it. When fully eftimated,

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it depoſites thin bright cryſtals, like the boracic acid: when half the quantity is evaporated, it affords, by cooling, flat cryſtals, which are either hexagonal, or triangular, or ſquare, and appear to conſiſt of a great many ſmall needles joined laterally. Theſe flat cryſtals are obliquely arranged one over another. They are tranſparent and very cauſtic. They are called *Lunar cryſtals:* their proper name is nitrate of ſilver. This ſalt is ſpeedily altered by the contact of light, and rendered black by combuſtible vapours. When placed on a burning coal, it readily detonizes, leaving after the detonation a white powder, which conſiſts of pure ſilver: it is very fuſible. If expoſed to fire in a crucible, it ſwells at firſt as it loſes the water of its cryſtallization; and after that, remains in fuſion without motion. If ſuffered to cool in this ſtate, it becomes a grey maſs, ſlightly needled; a preparation which is known in ſurgery under the name of *Lapis infernalis.* But there is no occaſion to make uſe of cryſtallized nitrate of ſilver when we wiſh to obtain this medicine; the proceſs by which it is made up is too tedious, and too expenſive. It is ſufficient to evaporate to dryneſs a ſolution of ſilver by the nitric acid, to put the reſidue in a ſilver crucible or ladle, as M. Baumé adviſes, and to heat it ſlowly till it melt: it may be then run into a mould, to give it the form of ſmall cylinders. When theſe cylinders are broken, they appear to conſiſt of needles diverging in radii from the centre of the cylinder, and terminating at its circumference. In compoſing the *infernal ſtone* of nitrate of ſilver, we muſt beware of heating it too long; otherwiſe a part of the ſalt will be decompoſed, and formed into a button at the bottom of

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the crucible. In order to have an opportunity of observing what passes in this operation, I distilled this salt in a pneumato-chemical apparatus; I obtained nitrous gas and vital air, mixed with azotic gas. In my matrass I found the silver entirely reduced; the glass was become opaque, like enamel, and was of a beautiful chesnut-brown colour. The brown colour which the glass takes on this occasion must, no doubt, be owing to oxide of manganese, or some other substance contained in it; for the colour of glass formed of oxide of silver is nearly an olive green, as we have already observed.

Nitrate of silver does not attract moisture when exposed to the air; it dissolves very readily in water; and may be crystallized from the solution by a slow evaporation of the fluid.

The nitric solution of silver is decomposed by salino-terrene substances and alkalis; but the phænomena vary greatly, according to the state of these matters. Lime-water produces a very copious olive-coloured precipitate. Fixed alkali, saturated with carbonic acid, makes it yield a white precipitate: caustic ammoniac causes it to afford a grey precipitate, inclining to olive-green. This precipitation does not take place till a considerable time after the two substances have been mixed.

Although the nitric acid act with a stronger energy on silver than any of the other acids, there are, however, others which have a greater affinity with its oxide, and adhere to it with more obstinacy: the sulphuric and the muriatic acids detach the oxide from the nitric acid. For this reason, when a few drops of either of these acids are

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poured into a nitric solution of silver, a precipitate is produced; which, when the sulphuric acid is employed, is a white powder; and when it owes its origin to the muriatic acid, is in thick flakes like a *coagulum*. In the former case, the precipitate is sulphate of silver; in the latter, muriate of silver. As neither of these two salts is very liable to solution, they therefore subside in a precipitate. It is not necessary that the acids be in a state of liberty when applied to this purpose; the neutral salts, which are formed by their combinations with alkalis and salino-terrene substances, serve the purpose equally well. A double decomposition and a double combination then take place; for the nitric acid, separated from the silver, enters into combination with the base of the sulphuric or muriatic salt.

On this difference among the acids, in respect to the manner in which they act upon silver, there is founded a process which is employed to procure the nitric acid in an high state of purity, and unmixed with any other acid: in a word, in that state in which it is requisite to have it for many operations in metallurgy, and for most chemical experiments. Distilled spirit of nitre is generally mixed with a certain quantity of sulphuric or muriatic acid; and chemists have therefore industriously sought to separate these extraneous fluids, and have found no happier expedient than the use of the nitric solution of silver. This solution is poured into the impure nitric acid till it cease to produce a precipitate; the sediment of sulphate or muriate of silver is suffered to settle; the acid is decanted off, and distilled by a moderate heat, to separate from it that small quantity of salts of silver which may still be contained in it. The produ-

duct of this distillation is very pure nitric acid: in the arts it is called *precipitated aquafortis.*

Most metallic matters are capable of decomposing the nitric solution of silver, as they have in general a greater affinity than that metal with oxigene. Arseniate of potash, dissolved in water, produces in the nitric solution a reddish precipitate, which originates from the union of the silver with the arsenic acid. This precipitate resembles red silver ore. The silver may be obtaintained in its metallic state, as a precipitate from this solution, by most of the metals and the semi-metals. But the separation of this perfect metal by mercury and copper is particularly worthy of our notice, on account of the phænomena which attend the first of these metallic substances, as it acts on silver, and the useful purposes which are served by bringing the second to act upon it.

Silver, when separated from the nitric acid by mercury, is in a metallic state; and the precipitate subsiding slowly, produces, as it subsides, a regular figure, known by the name of *Diana's tree*, or *the philosophic tree.*— This species of crystallization may be obtained by several different processes. Lemery directed to take an ounce of fine silver, to dissolve it in nitric acid moderately strong, and to dilute the solution with about twenty ounces of distilled water, adding two ounces of mercury. In the space of forty days a very beautiful vegetative form is produced. Homberg gives another process, much shorter than this. His process is, to make a cold amalgam of four drachms of silver in leaves, with two drachms of mercury: this amalgam is to be dissolved in a sufficient quantity of nitric acid, and a pound and an half of distilled water to be added to the solution: into

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an ounce of this liquor put a ſmall ball of a ſoft amalgam of ſilver, and the precipitation of ſilver will immediately take place. The ſilver being precipitated and combined with a part of the mercury, is depoſited in a kind of priſmatic filaments on the ſurface of the amalgam. Other filaments riſe above the firſt, ſo as to preſent a kind of vegetation in the form of a buſh. Laſtly, M. Baumé has deſcribed a way of obtaining a tree of Diana, a little different from Homberg's proceſs, and more infallibly attended with ſucceſs. He directs to mix ſix drachms of the ſolution of ſilver, and four drachms of a ſolution of mercury, by the nitric acid, both fully ſaturated; to add to the mixture five ounces of diſtilled water; and then to pour it into an earthen veſſel, upon ſix drachms of amalgam, made up of ſeven parts of mercury, with one of ſilver. Either of theſe proceſſes ſucceeds in a much ſhorter time than Lemery's, in conſequence of the relation ſubſiſting between the metallic matters and their mutual action. In fact, the mercury contained in the ſolution attracts the mercury of the amalgam; the ſilver of the amalgam acts in the ſame way on the ſilver of the ſolution: and of conſequence the ſilver is more ſpeedily precipitated. The mercury of the amalgam, being more than is requiſite to precipitate the ſilver of the ſolution, produces a third effect, which we muſt not ſuffer to eſcape unnoticed: It attracts the ſilver by its affinity and tendency to combine with that metal: a combination is actually effected between them; for the vegetation of the tree of Diana is a real amalgam, brittle and cryſtallized. This cryſtallization ſucceeds much better in conical veſſels, ſuch as glaſſes, than in round or wide veſſels, like the cucurbite

recommended

commended by M. Baumé. It is almoſt unneceſſary to mention, that the veſſel muſt not be moved, nor expoſed to any impulſe which might hinder the regular ſymmetrical arrangement of the amalgam.

Copper immerſed into a ſolution of ſilver likewiſe precipitates it in a bright metallic form. This is the proceſs uſually employed to ſeparate ſilver from its ſolvent, after the operation of parting. Plates of copper are dipped into the ſolution, or rather the ſolution is put into a copper veſſel; the ſilver is immediately ſeparated in whitiſh grey flakes. When the liquor becomes blue, and ceaſes to precipitate ſilver, it is decanted off. The ſilver precipitated is repeatedly waſhed, then melted in crucibles, and paſſed with lead into a cupel, to ſeparate from it a portion of copper, which became united with it in the precipitation. The ſilver which paſſes through this operation is purer than any other kind: it is no leſs than twelve penny-weights fine. From theſe two caſes of the precipitation of ſilver by mercury and by copper, it appears that metals ſeparated from their ſolvents by metallic matters, are precipitated with all their properties. This phænomenon, as we have ſhown in the hiſtory of copper, takes place in conſequence of the metals immerſed into the ſolution of ſilver, robbing it of its oxigene, with which they have a greater affinity.

The muriatic acid does not diſſolve ſilver immediately; but it diſſolves its oxide readily enough. This acid, ſuperſaturated with oxigene, eaſily oxidates the metal. Such, no doubt, is the reaſon of what happens in the *concentrated parting*. This operation conſiſts in expoſing to fire, plates of gold alloyed with ſilver, cemented with

a mixture of sulphate of iron and muriate of soda: The sulphuric acid, disengaging the muriatic, communicates to it a portion of its own oxigene; and the muriatic acid then acts upon the silver, and dissolves it.

There is a much easier and more expeditious process for combining the muriatic acid with oxide of silver. The acid is poured into a nitric solution of the metal: a very copious precipitate is instantaneously formed, and proves to be a combination of the muriatic acid with silver; for the metal has a greater affinity with the muriatic than with the nitric acid, and of consequence forsakes the latter to combine with the former. The same combination may be obtained by pouring muriatic acid into a solution of sulphate of silver; for this acid has likewise a greater affinity than the sulphuric with the metal. The muriatic acid may also be combined with silver, by heating the acid with oxide of the metal precipitated from the nitric acid by fixed alkali.

Muriate of silver possesses various properties worthy of notice. It is remarkably fusible. When exposed in a phial to a moderate heat, such as that of hot ashes, it melts into a grey semi-transparent substance, bearing no small resemblance to horn; and for this reason called *luna cornea*. If run upon a surface of porphyry, it fixes into a friable matter, appearing to be crystallized in fine silver needles. When long heated in contact with air, it is decomposed; it passes easily through the crucibles; one part of it is volatilized, and another reduced to metal; so that it now takes the form of silver globules dispersed through muriate of silver; a portion of the salt remaining not decomposed. This salt, when

exposed

exposed to light, loses its whiteness, and becomes speedily brown. It dissolves in water; but, according to an experiment of M. Monnet's, a pound of distilled water dissolves only three or four grains. Alkalis are capable of decomposing muriate of silver, when it is either dissolved in water, or exposed to fire, together with any of these salts. This is one way of obtaining the finest and purest silver possible. Mix, for this purpose, four parts of potash, or carbonate of potash, with one of muriate of silver: Put the mixture into a crucible, and melt it; when it is completely melted, take it out of the fire; suffer it to cool, and then break it: separate the silver; which is found under the muriate of potash formed during this operation, and the excess of alkali. M. Baumé, to whom we owe this process, asserts, that the quantity of alkali which he directs to be employed, hinders the muriate of silver from passing through the crucible, by acting on all its parts, and decomposing them at once. Margraff has given another process for reducing this salt, and obtaining from it silver perfectly pure. Triturate in a mortar five drachms and sixteen grains of muriate of silver, with an ounce and an half of ammoniacal carbonate, and as much distilled water as may be sufficient for making it into a paste: stir this mixture till the swelling and effervescence which at first take place in it cease: then add three ounces of pure mercury, and triturate the whole till it be formed into a beautiful amalgam of silver: wash it with a good quantity of water; continue the trituration, and repeat the washing till the water run off very clear, and the amalgam become very bright: then dry the amalgam, and distil it in a retort till the vessel take a white red colour: the

mercury now paſſes into the receiver, and the ſilver is found in an high ſtate of purity at the bottom of the retort. In this manner the metal may be obtained of the higheſt purity poſſible, and without any ſenſible loſs. This ſort of ſilver ſhould be uſed in nice chemical experiments. The water employed to waſh this mixture carries off two ſubſtances; a certain quantity of ammoniacal muriate, which it holds in ſolution, and a white powder not ſoluble in water. When the white powder is ſublimated, there is a ſmall quantity of ſilver found at the bottom of the ſublimatory veſſel. This experiment proves, that muriate of ſilver cannot be completely decompoſed otherwiſe than by double affinity. In fact, in Margraff's proceſs, the cauſe of the ammoniac combining with the muriatic acid is, that the ſilver is firſt detached from the acid by the mercury, and the alkali then becomes capable of effecting an event which it could not otherwiſe have produced. But this tedious and expenſive operation can only be employed in the ſmall way, and in the laboratory. To reduce a great quantity of muriate of ſilver at once, either fixed alkali, or ſome metallic ſubſtance having a greater affinity than ſilver with the muriatic acid, muſt be employed. Such, among others, are antimony, lead, tin, iron, &c. One part of muriate of ſilver melted in a crucible, with three parts of any of theſe matters, affords, at the bottom of the crucible, the ſilver reduced and ſeparate; while the metal employed to produce the ſeparation appears in union with the muriatic acid. The ſilver precipitated in this manner is very impure; it always contains more or leſs of the metal employed to ſeparate it; and as, in compliance with the advice of Kunckel, lead

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is moſt commonly employed for the purpoſe, this ſilver needs to be cupelled; nor can it even be rendered equally pure with that which is reduced by alkalis, or by Margraff's proceſs.

The nitro-muriatic acid acts with conſiderable force on ſilver; and, as it diſſolves it, cauſes it to precipitate. The manner in which this effect takes place may be eaſily underſtood: the nitric acid diſſolves the metal at the firſt, and the muriatic acid, detaching itſelf from the nitric, forms a neutral ſalt with the ſilver; which, having no great tendency to ſolution, is depoſited in ſediment. This proceſs may be uſed to ſeparate ſilver from gold.

We know but little about the manner in which the other acids act upon ſilver; only, a ſolution of borax produces in the nitric ſolution of this metal a very copious white precipitate; which precipitate conſiſts of boracic acid in union with oxide of ſilver.

This metal does not appear liable to be altered by neutral ſalts. It is certain, at leaſt, that it does not detonize with nitre, nor decompoſe ammoniacal muriate. Silver, in conſequence of its being unalterable by nitre, may be eaſily ſeparated from imperfect metals, ſuch as copper, lead, &c. by detonizing them with that ſalt. This metal, alloyed above the juſt proportion with ſome of the baſer metals, is melted with nitre: the ſalt detonizing burns the imperfect metal; and the ſilver falls to the bottom of the crucible in a ſtate of much higher purity.

Almoſt all combuſtible matters act with more or leſs force on ſilver. No metal is ſooner tarniſhed or coloured by inflammable matters. Sulphurated hydrogenous

gas, from whatever ſubſtance diſengaged, communicates to ſilver, the inſtant it comes into contact with it, a blue or violet colour, inclining to black, and conſiderably diminiſhes its ductility. It is known that fœtid animal vapours, ſuch as proceed from houſes of office, from putrefied urine, and from hot eggs, produce the ſame effect on this metal. The mutual action of theſe bodies, and the combination which takes place on the occaſion, have not yet been examined.

Sulphur combines very readily with ſilver. This combination is uſually effected by ſtratifying on a crucible plates of the metal with flowers of ſulphur, and melting the mixture haſtily: the reſult is a violet black maſs, much more fuſible than ſilver, brittle, and needled; in a word, a true artificial ore. This compoſition is eaſily decompoſed by the action of fire, on account of the volatility of ſulphur, and the fixity of ſilver: the ſulphur is conſumed and diſſipated, leaving the ſilver pure. Alkaline ſulphure diſſolves this metal in the dry way: on melting one part of ſilver with three of ſulphure of potaſh, the metal diſappears, and may be diſſolved in water together with the ſulphure. An acid poured into the ſolution produces a black precipitate of ſulphurated ſilver. Leaves of ſilver put into a ſolution of ſulphure of potaſh ſpeedily take a black colour; and it appears that the ſulphure forſakes the alkali, to unite with the metal and mineralize it; as we have already obſerved of mercury.

Arſenic combines with ſilver, and renders it brittle. We know not yet how the acid of arſenic affects this metal.

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It combines, but not without great difficulty, with cobalt.

It enters readily enough into an alloy with bismuth, forming with it a brittle mixed metal, the specific gravity of which is greater than that of either of the two metals taken separately. According to Cronstedt, silver does not unite with nickel. These metals, when melted together, are disposed separately, one beside the other, as if their specific gravities were precisely equal.

It melts with antimony into a very brittle alloy. It appears to be capable of decomposing sulphure of antimony, by combining with the sulphur of that mineral, with which it has a greater affinity than antimony has.

Silver easily combines with zinc by fusion. From this combination there results an alloy granulated at the surface, and very brittle.

In mercury, even cold, it is completely dissolved. All that is necessary to effect this solution, is to malaxate leaves of silver with this metallic fluid: an amalgam is by this means instantaneously produced; the consistency of which varies with the respective quantities of the two substances. This amalgam may be brought into a regular form by fusion and slow evaporation: it affords tetrahœdral prismatic crystals, terminating in pyramids of the same form. The mercury becomes in some degree fixed in this combination: for, to separate it from the silver, a stronger heat is required than what is sufficient to volatilize it when taken by itself. Silver decomposes corrosive mercurial muriate, either in the dry or in the humid way.

It unites perfectly with tin: but entirely loses its duc-

tility when alloyed with ever ſo ſmall a proportion of that metal.

It enters readily into union with lead, which renders it very fuſible, and deſtroys its elaſticity and ſonorouſneſs.

It forms an alloy with iron, which might perhaps be very advantageouſly employed in the arts.

Laſtly, It melts and combines in any proportion with copper. Copper does not deſtroy its ductility; but renders it harder and more ſonorous; and the alloy is often employed in the arts.

Silver, on account of its ductility, and its being proof againſt the attacks of fire and air, is a metal ſingularly uſeful. Its luſtre recommends it for an ornament: it is laid on the ſurfaces of various bodies, and even of copper: it is wrought into ſtuffs, and adds conſiderably to their beauty. But the moſt important uſe for which it ſerves, is that of a good material out of which veſſels of all kinds may be made; and its hardneſs and ductility render it peculiarly ſuitable for this purpoſe. The ſilver wrought into plate is commonly alloyed with $\frac{1}{24}$ of copper, which improves its hardneſs and coheſion, without rendering it in any degree dangerous to the health of thoſe who uſe it; for twenty-three parts of ſilver are ſufficient to deſtroy all the noxious qualities of one part of copper.

Laſtly, Silver is coined into money, and uſed as a ſign of value for all ſorts of commodities; but in this caſe it is alloyed with $\frac{1}{12}$ of copper, and is, of conſequence only eleven penny-weights fine.

* Britiſh ſilver money is 11 penny-weights 2 grains fine. H.

CHAP.

CHAP. XXI.

Of Gold.

GOLD, the ſun of the alchemiſts, is of all known metals the moſt perfect, and the leaſt liable to alteration: its colour is a bright yellow. It is, next after platina, the moſt ponderous body in nature: In water it loſes only between a nineteenth and a twentieth part of its weight: neither its hardneſs nor its elaſticity is very conſiderable. Its ductility, of which gilding and gold wire afford ſuch amazing proofs, is ſo great, that an ounce of gold is ſufficient to gild a ſilver wire four hundred and forty-four leagues in length; and it is reducible into leaves that may be carried about before the wind. It is calculated by Lewis, that a grain of gold will cover an area more than fourteen hundred inches ſquare. It is the moſt tenacious of all metals; for a wire of gold one tenth of an inch in diameter, is ſufficient to ſupport five hundred pounds weight without breaking. Gold ſoon becomes hard and brittle under the hammer; but heat reſtores its ductility.

The colour of gold is ſubject to a good many varieties. It is ſometimes more or leſs yellow or pale, and ſometimes almoſt white: theſe differences, however, appear to be owing to ſome mixture. Gold has neither taſte nor ſmell: It cryſtallizes by cooling into ſhort quadrangular pyramids. Meſſrs Tillet and Mongez obtained it in this form.

Gold is found in nature almoſt conſtantly in a pure and virgin ſtate. It is ſometimes met with in ſmall maſſes, either ſolitary or continuous, and in a bed of quartz: At other times it is in ſmall ſpangles, among ſand, at the bottom of rivers. Laſtly, It is extracted from various ores, into the compoſition of which it enters; ſuch as galena, blende, red ſilver ore, and virgin ſilver. It is almoſt always united with a certain quantity of ſilver, or ſome other metal, forming thus a natural alloy.

There are ſeveral varieties of native gold. It exiſts in plates, in grains, in cryſtals; which are either octahædral, in priſms of four faces, or ſtriated in filaments, and in irregular maſſes. M. Sage thinks, that native gold in priſms is combined with a certain quantity of mercury, which renders it brittle.

Modern mineralogiſts reckon up various ſpecies of gold.

1. Native gold in union with ſilver, copper, iron, &c. It is found in Peru, Mexico, Hungary, Tranſylvania, &c.

2. Auriferous pyrites: It is not eaſily diſtinguiſhed from other pyrites by the eye: we diſcover the gold by diſſolving it in the nitric acid, and waſhing the reſidue. Gold is only mixed, not combined, in martial pyrites.

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Some arsenical pyrites, particularly those of Saltzbergh in Tyrol, contain likewise a little gold.

3. Gold mixed with silver, lead, and iron mineralized by sulphur. This auriferous ore is of a very mixed nature. According to M. Sage, it is found to contain blende, galena, specular antimony, copper, silver, and iron; the gold melts, and drops out with the lead, when the mass is exposed to heat. It comes from Naggyac in Transylvania.

Gold ore is assayed in different ways, according to its nature; pulverization and washing are sufficient with native gold. Gold alloyed with other metals must be roasted, melted, and cupelled with lead, and parted.

It is very easy to conceive in what way gold is extracted from its ores, after what has been already said on metallurgy in this work. Native gold needs only to be separated from its gangue. For this purpose, it is first pounded; then washed, to separate the powder of the gangue; then triturated in a mortar full of water, with 10 or 12 parts of mercury; the water being poured off after this operation, washes away every earthy particle from the metallic substance When the amalgam, thus formed, appears to be sufficiently purified from earth, it is strained through goat-skins. Great part of the mercury passes through; a certain quantity remains still united with the gold. The amalgam is next heated, and the mercury separated from it by distillation; the pure gold obtained by this distillation is then melted, and run into bars or ingots. With respect to the gold that is found in combination in the ores of

other metals, ſuch as lead, copper, ſilver, it is extracted by eliquation, cupellation, and parting. The lead which runs down from the eliquation of copper, carries with it the ſilver and the gold. It is then cupelled, to ſeparate the lead; and the ſilver, as we ſhall hereafter mention, is ſeparated by parting.

Gold expoſed to fire becomes red-hot before it melts. When very red, it aſſumes a dazzling luſtre, and a clear green colour, like that of the aqua-marina. It does not melt till its colour change to a white red; when cooled ſlowly it cryſtallizes. It ſuffers no alteration, however long it be expoſed to fire, and however intenſe the heat; for Kunckel and Boyle found gold to have undergone no alteration by being expoſed for ſeveral months to the fire of a glaſs-houſe. This inalterability of nature is only relative, however, to the degrees of heat which we are capable of applying to it by the uſe of combuſtible matters; for it appears that a much more intenſe and active heat, ſuch as that of glaſs lenſes, deſtroys the metallic properties of gold. Homberg obſerved, on expoſing this metal to the focus of a lens of Tſchirnhauſen's, that it ſmoked, became volatile, and was even vitrified. Macquer obſerved, on expoſing gold to the focus of M. Trudaine's lens, that it melted, and exhaled a ſmoke which gilded ſilver, and could therefore be nothing but gold volatilized; that the globule of melted gold was agitated by a rapid internal motion, and became covered with a rough pellicle, ſhrivelled, and ſeemingly earthy; and that a violet-coloured vitrification was at length formed in the middle of the gold. The vitrified part was by degrees enlarged, till it formed a kind of cap of a larger curvature than the globule

of

of gold, and closely enchased in the gold in the same manner as the transparent cornea appears enchased in the sclerotica of the eye The extent of the glass became gradually larger, and the gold was diminished. The surface on which it rests is always coloured with a purple tinge, which seems to be owing to the glass which it has absorbed.

Time did not allow Macquer to vitrify a given quantity of gold completely. He observed, that it would be necessary to reduce the violet glass with combustible matters, in order to know whether it would afford gold, and whether it were oxide of that perfect metal. At any rate, we are of opinion, that vitrified gold may be considered as a true oxide of gold; and we are the rather induced to adopt this opinion, because in a number of operations, which we shall immediately proceed to describe, it invariably takes a purple colour; and several preparations of it are used for giving this colour to enamel and porcelain. Gold, then, like other metallic matters, may be reduced to calx; only, like silver, it requires a more intense heat, and longer time to make it combine with the base of vital air, than any other metallic matter: these circumstances, no doubt, bear a near relation to its extraordinary density, and its faint tendency or aversion to combine with oxigene. It is reduced to a purplish oxide by electrifying it violently.

Gold suffers no alteration from the action of air. Its surface is only tarnished by the extraneous bodies which are continually floating in the atmosphere. Water does not alter it in any way; from the experiments of Garaye, however, it appears that this sub-

stance

ſtance gradually divides it in the ſame manner as iron.

Gold in its metallic ſtate does not combine with earths or ſalino-terrene ſubſtances. Its oxide enters into the compoſition of glaſſes, and communicates to them a violet or purple colour.

Gold is not liable to ſuffer from the attacks of the ſulphuric acid, however highly concentrated, and even aſſiſted by heat.

The nitric acid diſſolves a few particles of this metal; but it is perhaps rather mechanically than by true combination. Brandt was among the firſt chemiſts who aſſerted gold to be ſoluble in the nitric acid: the fact has been ſince confirmed by the experiments of Scheffer and Bergman. But we muſt obſerve, that, according to experiments made by the whole chemiſts of the Academy of Paris, the nitric acid produces this effect only in certain circumſtances. M. Deyeux, member of the College of Pharmacy, has remarked, that the acid of nitre diſſolves gold, only when it is ruddy, and contains nitrous gas. According to him, the acid is not pure in this ſtate: he calls it *acid impregnated with gas*, and deſcribes it as a kind of *aqua-regia*. We have elſewhere ſhown in what conſiſts the difference between the nitrous and the nitric acid.

The muriatic acid alone, and in a ſtate of purity, acts not upon gold in any ſenſible degree. Scheele and Bergman have diſcovered, that the oxigenated muriatic acid diſſolves gold in the ſame way as *aqua-regia*; and forms alſo with the metal the ſame ſalt which it forms with the mixed acid uſually employed to diſſolve it. It is the exceſs of oxigene united with the muriatic acid which

cauſes

causes the solution to take place: it it accompanied with no sensible effervescence, like the other solutions of metals, by the oxigenated muriatic acid.

Aqua-regia has been considered as the true solvent of gold. It dissolves it, however, no better than the oxigenated muriatic acid. As it would be improper to repeat here what we have elsewhere said concerning the nature and properties of this mixed acid, and the varieties to which it is liable, according as the proportions of the two acids by the combination of which it is formed vary, we shall speak only of the manner in which it acts upon gold. As soon as the nitro-muriatic acid comes into contact with this metal, attacks it with an effervescence; which, the more concentrated the acid, the hotter the temperature, and the more divided the integrant parts of the gold, is so much the more lively. This operation may be more speedily effected by a moderate heat; at least a moderate heat is favourable in the beginning of the process. Bubbles then rise in constant succession, till a part of the metal be dissolved. This action by degrees ceases; stirring or heat is requisite to make it continue. Nitrous gas is disengaged while the solution is taking place. The nitro-muriatic acid, when saturated with the full quantity of gold which it is capable of dissolving, takes a yellow colour of a lighter or a deeper shade. It is considerably caustic; it tinges animal matters with a deep purple colour, and corrodes them. When evaporated with proper management, it affords crystals of a beautiful golden colour, resembling topazes, and appearing to be truncated octahædrons, and sometimes tetrahædral prisms. It is difficult enough to obtain this crystallization. M. Monnet thinks it

owing to a neutral ſalt, ready formed in the nitro-muriatic acid; and aſſerts, that in order to obtain it, the *aqua-regia* made uſe of ſhould be compoſed of nitric acid with ammoniacal muriate, or muriate of ſoda. A mixed acid prepared in this manner cannot but contain nitrate of of ſoda, or ammoniacal nitrate. It is either the one or the other of theſe neutral ſalts, according to the chemiſt whoſe opinion we are mentioning, which occaſions the cryſtallization of gold. It appears, however, that a ſolution of gold in nitro-muriatic acid, made up of pure acids, is capable of affording cryſtals; and Bergman conſiders the ſalt as muriate of gold. Theſe cryſtals, when heated, melt and take a red colour. This ſalt powerfully attracts the moiſture of the atmoſphere. A ſolution of gold gives, by diſtillation, a beautiful red colour, whichis nothing but muriatic acid impregnated with a little gold. The alchemiſts who have laboured ſo much upon gold, called this liquor *red lion.* A few golden cryſtals are likewiſe ſublimated, the colour of which is a reddiſh yellow. Moſt part of the metal remains at the bottom of the crucible; and fuſion purifies it, ſo that it again diſplays all its properties.

The ſolution of gold may be decompoſed by a great many intermedia. Lime and magneſia precipitate the gold in the form of a yellowiſh powder. Fixed alkalis afford the ſame phænomenon. But it is to be obſerved, that the precipitate is but very ſlowly formed; and the ſolution takes a reddiſh colour, if more alkali be employed than what is abſolutely requiſite; for the exceſs of alkali again diſſolves the precipitated gold. The precipitate of gold may be reduced by heat in cloſe veſſels; it is an oxide which readily gives out its oxigene in the ſtate

of

of vital air. This oxide, however, is fusible with vitreous matters, and communicates to them a purple colour; for enamels and porcelain are coloured with a precipitate of gold, formed by mixing a solution of gold with liquor of flints.

Gold precipitated by fixed alkali exhibits likewise another property, very different from those which gold possesses in its metallic state: it is soluble in pure sulphuric, nitric, or muriatic acid. All of these acids, when heated on the yellowish precipitate of gold, readily dissolve it; but they do not take up so much of it as to afford crystals. When these solutions are evaporated, the gold is very quickly precipitated; the same thing happens by rest. M. Monnet has observed a fact concerning the precipitation of gold by nut-gall *, which must not be forgotten; it is, that the precipitate which is reddish, dissolves very well in the nitric acid, and communicates to it a beautiful blue colour.

* As we have taken notice only of the precipitation of iron by nut-gall, we shall give a short account of the phænomena which this astringent substance exhibit with most other metallic substances.

Nut-gall, with the solution of cobalt, gives a clear blue precipitate; with the solution of zinc, an ash-green precipitate; with the solution of copper, a green precipitate, which becomes grey and reddish; with a solution of silver, it gives first reddish striæ, which take afterwards the colour of burnt coffee; with the solution of gold, a purple precipitate. These facts have been observed and described by M. Monnet; and he has observed farther, that these precipitates are soluble in acids; and that alkalis combine with the latter solutions without producing precipitates.

The academicians of Dijon have added to these facts the following new observations. 1. The solution of arsenic is not altered by nut-

Ammoniac precipitates the solution of gold in much greater abundance. This precipitate is of a brown yellow, and sometimes of an orange colour; when exposed even to a moderate heat, it detonizes with a considerable noise; it has been called *fulminating gold.* Ammoniac is indispensibly necessary to its production. It may be formed, either by precipitating, by fixed alkali, a solution of gold made in nitro-muriatic acid, composed with ammoniacal muriate; or rather, by precipitating, by ammoniac, a solution of gold made in aqua-regia, composed of pure nitric and muriatic acid. The fulminating gold thus obtained is always one fourth more in quantity than the gold dissolved in the *aqua-regia.* There are some precautions necessary to be taken in order to escape suffering from the terrible effects of fulminating gold. In the first place, it must be dried cautiously, and in the open air, at a distance from any fire; for a very moderate degree of heat is sufficient to make it fulminate. As friction alone would be enough to make it give an explosion

gall; with the solution of bismuth, nut-gall produces a greenish precipitate; with the solution of nickel, a white precipitate; with the solution of antimony, a bluish grey precipitate; with lead, a flaty sediment, the surface of which is covered with pellicles of a mixed green and red colour; lastly, the solution of tin takes a dirty grey colour, by mixture with nut-gall, and gives a copious precipitate, somewhat of a mucilaginous nature. Under the article of the Gallic Acid, or acid of galls, in the vegetable kingdoms, several of these facts will again draw our attention.

It may be proper to observe here, that the experiments of M. Monnet, and of the academicians of Dijon, were made with a decoction of the nut-gall: whilst those which will be taken notice of in the vegetable kingdom, refer to the action of the *gallic acid* on metallic solutions, which accounts for the difference of the results in the two cases. F.

ſion, the veſſels into which it is put muſt be ſtopped only with cork. Some unlucky accidents have ſhewn, that cryſtal ſtoppers, by their friction on the necks of the bottles, may cauſe ſuch particles of the powder as adhere to that part of the bottle to fulminate; and by communication with the reſt of the powder, to produce the moſt dangerous effects. A terrible accident happened in M. Baumé's laboratory, of which he has given an account in his *Theory and Practice of Chemiſtry*.

Chemiſts have entertained various opinions concerning the cauſe of the detonation of fulminating gold. Baumé gave it as his opinion, that in this inſtance there was formed *nitrous ſulphure*, which he conſidered as the fulminating principle of this compound. But Bergman has proved his theory inadmiſſible, having formed fulminating gold without nitric acid, by diſſolving a precipitate of gold in ſulphuric acid, and precipitating it anew by ammonaic. Neither can the fulmination of this gold be owing to ammoniacal nitrate; for after being copiouſly waſhed in water, which would certainly carry off any portion of that ſalt which it might contain, it ſtill retained its fulminating powers. On examining attentively what paſſes in the detonation of fulminating gold, it is obſerved to take fire at the very inſtant when it ſhivers into pieces. When it is expoſed to the moderate heat of warm aſhes, it gives out, before the exploſion, ſparks like thoſe of electric fire; when expoſed to the ſpark produced by the Leyden bottle, it detonizes; a ſimple ſpark without motion does not kindle it; laſtly, after fulminating, it leaves the gold in a metallic ſtate. It appears, therefore, that the fulmination of this gold is owing to ſome combuſtible matter contained in the com-

pound. And as ammoniacal gas is neceſſary to the production of fulminating gold, it is at preſent agreed, that the exploſion ought to be attributed to that ſubſtance. This theory is founded on the following facts.

1. M. Berthollet has obtained ammoniac gas by applying a gentle heat to copper tubes, containing fulminating gold, and communicating at one end by means of a ſyphon, with a pneumato-chemical apparatus with mercury. The gold was now no longer fulminating, but was reduced to oxide.

2. Bergman, having expoſed fulminating gold to a degree of heat not ſufficient to make it fulminate, gradually deprived it of its fulminating powers, by volatilizing the ammoniac gas which it contained.

3. When a few grains of fulminating gold are made to detonize in copper tubes, communicating with a pneumato-chemical apparatus with mercury, gas azote, and a few drops of water, are obtained as products, and the gold is found to be reduced. M. Berthollet, to whom we owe this fact, thinks that in this inſtance ammoniac is decompoſed; that the hydrogene which it contains, uniting with the oxigene of the oxide of gold, reduces it by forming water; and that the gas azote, being thus ſet at liberty, is conſequently diſengaged: the fulmination appears therefore to be owing to the combuſtion of hydrogene, and the ſudden diſengagement of gas azote.

4. The concentrated ſulphuric acid, melted ſulphur, fat oils, and æther, deprives this precipitate of its fulminating powers, by detaching its ammoniac.

A ſingular property of fulminating gold, which ſhows with

with what force it acts, is its making a mark or hole on any metal plate, ſuch as a plate of lead, tin, and even ſilver, on which it is fulminated. But it does not appear to be liable to take fire in a very cloſe veſſel; for Lewis relates, that it produced no exploſion when incloſed in an iron ball, and expoſed to an intenſe heat. The cauſe of this phænomenon ſeems to be, that there is not then room for the diſengagement of the gas azote. Bergman, who did not well know the nature of the gas diſengaged during the fulmination of this precipitate, and conſidered it as pure air impregnated with a little ammoniac, has given a ſimilar explanation of the experiments made on this matter before the Royal Society of London. The reader may conſult his valuable Diſſertation *de calce auri fulminante*, in his *Opuſcula*. M. Berthollet diſcovered that oxide of ſilver, precipitated from nitric acid by lime, and digeſted with ammoniac till it take a black colour, acquires the property of detonizing, not only by a heat a very little ſuperior to that of boiling water, but likewiſe by a ſlight friction againſt any body. Here, then, we have fulminating ſilver of a ſtill more ſingular nature than the gold ſo called; which, however, owes its fulminating properties to the ſame cauſe. The ammoniac decanted from above this oxide, depoſites, by ſlow evaporation, ſmall, bright, lamellated cryſtals, poſſeſſing the property of fulminating, even under water, by ſimple friction.

The ſolution of gold is precipitated by alkaline ſulphures. When the fixed alkali combines with the acid, the ſulphur that is precipitated unites with the gold; but this combination is not very permanent; it is enough to heat the gold, and the ſulphur is then volati-

lized, and the perfect metal left in a state of purity. It is proper to observe, that the gold precipitated from a solution by an intermedium, is perfectly pure, even more so than gold obtained by parting, being separated from the silver which it would otherwise have contained, in consequence of that metal being precipitated in the form of a muriate, even during the solution of the gold, as we have above observed.

Gold has not a greater affinity than all the other metals with the nitro-muriatic acid; on the contrary, almost any other metallic substance is capable of separating it from its solvent. Bismuth, zinc, and mercury, precipitate gold. A plate of tin immersed into a solution of gold separates this perfect metal into a powder of a deep violet colour, which is called purple precipitate of *Cassius*. This precipitate, which is used for painting on enamels and porcelain, is prepared by diluting a solution of tin in nitro-muriatic acid, with a large quantity of distilled water, and pouring upon it a few drops of a solution of gold. When the solutions are pretty much concentrated, there is instantaneously formed a precipitate of a red crimson colour, which in a very few days changes to purple: the precipitate is light, and somewhat mucilaginous; the liquor is filtrated, and the precipitate washed and dried. This matter is a compound of oxide of tin and oxide of gold; the preparation of it is one of the most singular operations of chemistry, on account of the variety and the inconstancy of the phænomena which attend it. Sometimes it affords a beautiful red precipitate; sometimes its colour is only a deep violet: and what is most surprising, it happens pretty often, that the mixture of these two so-

solutions

itions produces no precipitate. Macquer, to whom these varieties were very well known, observes, that they depend almost always on the state of the solution of tin employed. If the solution have been hastily effected, the metal is too much oxidated, and there is too little of it contained in the solution for the acid of the solution of gold to act upon it; for he attributes the formation of the purple precipitate of *Cassius* to the action of that acid upon the tin. According to him, to succeed in this operation, the solution employed must have been very slowly made, so as to contain as much tin as possible, without the metal being too much oxidated. He accordingly gives the following direction, for preparing the purple precipitate. Dissolve the tin, one part after another, in an acid consisting of two parts of nitric acid, and one of muriatic acid, with an equal weight of distilled water; on the other hand, dissolve with the help of heat, a quantity of very pure gold in another mixed acid, consisting of three parts of nitric and one of muriatic acid. Dilute this solution of tin in an hundred parts of distilled water; divide it into two parts; add to one of them a new quantity of water, and try both of them with a drop of the solution of gold; observe then which of them affords the most beautiful red, and treat the other in the same manner with it; then pour in the solution of gold till it cease to afford a precipitate.

Lead, iron, copper, and silver, possess likewise the property of separating gold from its solution. Lead and silver separate it into a dirty dark purple precipitate. By copper and iron it is precipitated with its metallic lustre. The nitric solution of silver, and that of sulphate

of iron, produce likewife a red or brown precipitate in a folution of gold.

Neutral falts act not in a very confpicuous manner on gold. Only it is obferved, that borax melted with this metal alters its colour, and gives it a ftrange palenefs: but nitre and muriate of foda reftore it to its former ftate. A folution of borax poured into a folution of gold, forms a precipitate of boracic acid, impregnated with gold.

Sulphur is incapable of combining with gold; and this mineral is therefore employed to feparate fuch other metals as happen to be united with gold, efpecially filver. The alloy is melted in a crucible; when it is fully melted, flowers of fulphur, or fulphur in powder, are caft on its furface: the fulphur melting, and combining with the filver, thus forms a blackifh fcoria, which fwims above the gold. It is to be obferved, that the two metals are never entirely feparated by this operation, which is called *dry parting*; and that it is applied only to lumps of filver containing too little gold to be worth the expence of parting by aqua-fortis.

Alkaline fulphure diffolves gold entirely. Stahl even thinks, that it was by fuch a procefs that Mofes made the Ifraelites drink the golden calf that they had worfhipped. In making this combination, a mixture, confifting of equal parts of fulphur and potafh, is haftily melted with a quantity of gold leaf, amounting to an eighth part of the weight of the whole mafs. This melted matter is poured upon a furface of porphyry, pulverized, and diluted with hot diftilled water; it now forms a yellowifh green folution, containing an auri-

ferous

ferous sulphure of potash. This metal may be precipitated by means of acids, and separated from the sulphur precipitated together with it, by heating it in open vessels.

Gold combines with most metallic matters; and in its combinations with them exhibits a number of important phænomena.

It unites with arsenic. This metal renders its contexture brittle, and its colour very pale. It is scarce possible to separate the arsenic entirely from this mixture; the gold seems to render it more fixed in its nature.

We are unacquainted with any alloy of gold with cobalt. It combines with bismuth, which renders it white and brittle; in the same manner with nickel and antimony. As these metals are all easily oxidated, and mostly fusible, they are easily separated from gold by the joint action of fire and air.

Sulphure of antimony has been loudly praised by the alchemists as a purifier of gold. When this metal is alloyed with any extraneous metallic substance, such as copper, iron, or silver, on melting with it sulphure of antimony, the sulphure unites with these substances, and separates them from the gold, which is found by itself at the bottom of the vessel. This gold, however, is alloyed with antimony; it is purified by heating it to a white red. The antimony is then volatilized; a very intense fire, however, is requisite to separate it entirely; and it is observed, the antimony carries with it some part of the gold. This process, which was so famous among the alchemists, is in no way preferable to

that in which ſulphur alone is employed for the ſame purpoſe.

Gold eaſily unites with zinc: the mixed metal reſulting from this union is the whiter, and the more brittle, in proportion as the quantity in which the zinc enters into the mixture is greater. An alloy conſiſting of equal parts of theſe two ſubſtances is of a very fine grain; and takes ſo beautiful a poliſh, that it has been recommended by Hellot as proper for making mirrors to teleſcopes, not liable to loſe their luſtre. When the zinc is ſeparated from the gold by calcination, the oxide of the zinc is reddiſh, and carries with it a little gold, as mentioned by Stahl.

Gold has a greater affinity than any other metallic ſubſtance with mercury, and decompoſes amalgams of any other metal with mercury. It unites with mercury in all proportions, forming with it an amalgam; which the greater the proportion of the gold, is ſo much the more ſolid and the higher coloured. This amalgam is liquified by heat, and cryſtallized by cooling, like almoſt all the other compounds of this kind. We know not well what regular form it takes. M. Sage ſays, that its cryſtals are like feathered ſilver; and that, when viewed through the magnifier, they appear to be quadrangular priſms. He aſſerts likewiſe, that the mercury becomes fixed in this combination. This amalgam is uſed for gilding in *water-gold*.

Although gold cannot be oxidated by the joint action of the air and the fires of our furnaces, it ſuffers that change, however, when heated with mercury. Mercury, with a forty-eighth part of gold, heated in a flat-bottomed matraſs with a very narrow neck, on a ſand-bath,

bath, in the ſame way as oxide of mercury is heated in preparing *precipitate per ſe*, is itſelf oxidated, and cauſes the ſame phænomenon to take place on the gold. The mixture is changed into a dark red powder; and this double oxide is obtained even much ſooner, according to M. Baumé, than oxide of mercury heated by itſelf.

Here, then, we have a metal which, though exceedingly difficult to oxidate by itſelf, haſtens and facilitates the oxidation of another metallic matter, which does not readily ſuffer ſuch a change by itſelf.

Gold enters very readily into union with tin and lead: either of theſe metals totally deſtroys its ductility. With iron it forms a very hard alloy, of which, inſtruments for cutting may be formed much ſuperior to thoſe which are made of pure ſteel. This mixed metal is grey, and ſubject to the attraction of the magnet. Lewis propoſes the uſe of gold to ſolder ſmall pieces of ſteel neatly, and in a very ſolid manner.

Gold combines with copper, which renders it red, hard, and more fuſible. This alloy is fixed at different proportions for pieces of money, veſſels, and oys.

Laſtly, Gold combines with ſilver, which changes its colour, and renders it very pale. A certain difficulty, however, attends this mixture, on account of the different gravities of the two metals; as has been obſerved by Homberg, who ſaw them ſeparate when melted together. The alloy of ſilver with gold forms the jeweller's *green gold*.

As the uſe of gold is very extenſive, and as men have agreed to uſe gold and ſilver as common ſigns to repreſent

represent the value of all the other productions of nature and art, it is of great importance to be able to distinguish the degree of the purity of any piece of this metal, in order to the prevention of fraud, and that all the gold which circulates in commerce may be nearly of the same intrinsic value. Just and severe laws have prescribed the particular alloy of gold to be employed in making utensils, and have pointed out the proportions requisite to give it a due degree of hardness and inflexibility for that purpose. Chemistry affords means for distinguishing with what quantity of any other metal, gold may be at any time alloyed. The operation by which this is accomplished is called *the assay of gold*. Twenty-four grains of the gold to be assayed are cupelled for this purpose, with forty-eight grains of silver, and four drachms of pure lead. The lead as it vitrifies carries off with it the imperfect metals, such as copper, &c. The gold remains, after the cupellation, in combination with the silver. These two metals again are separated by an operation which bears the name of *parting*. To part an alloy of gold and silver, is to separate the two metals by a solvent, which may act upon the silver without affecting the gold. Aquafortis is commonly used. The design in adding the silver to the gold was, that all the silver in the gold might be completely dissolved by the nitric acid; for experience has shown, that gold must contain at least twice its weight of silver, before the nitric acid can act so as to dissolve the silver totally. As three parts of silver are often added to the gold, this operation is called *quartation*, as the gold composes in fact but one-fourth part of the mixture,

mixture. The following is the way of performing this procefs of *parting*.

The cupelled alloy of gold and filver is firft hammered flat, care being taken to heat and turn it frequently, that it may not fplit, nor feparate into fmall parts, in confequence of becoming hard and brittle under the hammer: it is then rolled up in feathers in a fpiral form; in this form it is put into a fmall matrafs, and fix drams of precipitated aquafortis, unmixed with muriatic acid, but diluted with half that quantity of water, are poured upon it. The veffel is expofed to a moderate heat, till the mixture begin to effervefce. The filver is foon after diffolved, and the metallic coil takes a brown colour. When the acid ceafes to act, it is then decanted off; and a new quantity is poured upon the metal, and boiled on it till the filver be entirely diffolved. This fecond operation is called a *repetition*. The acid is then decanted off, and the fpiral piece of metal, now become very thin, and perforated with a great many holes, is wafhed; it is poured with water into a crucible; the water decanted off, the crucible made red-hot, and the gold now difplays all its properties. It is next weighed, and its weight fhows the degree of the finenefs of the gold. In order to know exactly what quantity of other metals gold contains, any mafs of gold whatever is fuppofed to confift of twenty-four parts, called *carats;* and to attain ftill greater accuracy, each carrat is divided into two and thirty parts, called *thirty-feconds of a carat*. If the gold thus affayed have loft one grain in twenty-four, the mafs to which it belonged is confidered as gold of twenty-three carats; if a grain and an half, it is then gold of

is given to the following preparation: Pieces of linen steeped in a solution of gold, dried and burnt. In making use of them, a wet cork is dipped in these ashes, and rubbed upon silver; on which the gold, being in a state of extreme division, readily fixes. We have already spoken of gilding with water-gold. To make use of it, the piece of copper to be gilded must first be well scoured with sand and a weak aquafortis, which the workmen call *second water;* it is then immersed into a very weak solution of mercury: the mercury being precipitated, causes the amalgam of gold, which is applied to the piece, after washing it with water, to carry away acid, to adhere. When the amalgam is uniformly extended over the copper, the piece is then heated on the coals, to volatilize the mercury; the operation is concluded by rubbing upon the gold gilder's wax, which is composed of *red bole*, *verdigris*, *alum*, or *martial vitriol*, with yellow wax, and heating the gilt piece for the last time to burn the wax.

The other uses of gold for toys and laces are sufficiently known, so that it is unnecessary for us to insist on them here. With respect to the medicinal virtues which have been ascribed to] it, the best physicians at present agree in denying their existence, and think that any effects produced by the several potable preparations of gold must have been owing not to the gold, but to other matters mixed with it in the solution.

CHAP.

A valuable gold mine has been lately discovered in Ireland. Gold is still found in spangles, in the brook of Glengonar, in Crawfurd-Muir, in Scotland. Gold exists naturally in all vegetables. It is highly probable, notwithstanding the experiments of the French Academy, that nitric acid, however pure, always dissolves a certain proportion of gold subjected to its action, in the ordinary process of parting. H.

CHAP. XXII.

Of Platina.

PLATINA, which has been known as a peculiar metal only during the last forty years, has not yet been found any where but in the gold-mines of America, particularly in that of Santa Fé, near Carthagena, and in the bailiwick of Choco in Peru. The Spaniards have given it this name from *plata*, which in their language signifies silver; comparing it with this metal, of which it has in fact the colour: But the name of *white gold* appears to agree much better with its nature than that of *small silver;* for in its properties it resembles gold much more than silver.

Before the period which we have mentioned, there were some toys of platina. But as this metal cannot be melted and wrought by itself, it is probable that the snuff-boxes, heads of canes, and other utensils of this kind, sold under the name of *platina*, were mixtures of that metal, with some other metallic substances; which, as we shall see, are necessary to render it fusible.

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The platina in cabinets is in the form of ſmall grains or ſpangles of a livid white, inclining at once to the colour both of iron and of ſilver. Theſe grains are mixed with various extraneous ſubſtances; they are found to contain ſpangles of gold, blackiſh ferruginous ſand; grains which, when viewed with the magnifier, appear to be ſcorified like *machcfer*, and ſome particles of mercury. The mercury is ſeparated from this mixture by heating it; waſhing carries off the ſand and the grains of iron; the iron may likewiſe be ſeparated by the magnet: after this there remains nothing but gold and platina, which may be eaſily ſeparated by picking, as Margraff has done. The grains of platina, when examined with the microſcope, appear, ſome of them triangular, others round and flat, like ſmall cakes. When hammered upon ſteel, moſt of them are found to be malleable and ductile: ſome of them break into pieces on ſuch an occaſion. Theſe, when narrowly examined, are found to be hollow, and to contain within, iron and a white powder. It is, doubtleſs, on the principle of their containing ferruginous particles, that the property which ſome grains of platina poſſeſs of being ſubject to the attraction of the loadſtone, however purified from ferruginous ſand, is to be accounted for.

This metal is very nearly as hard as iron. The ſpecific gravity of platina, mixed with the ſeveral extraneous matters which we have mentioned, is nearly equal to that of gold: in water it loſes from a ſixteenth to an eighteenth part of its weight. Buffon and M. Tillet, on comparing, by weight, equal bulks of platina and gold reduced to grains like thoſe of platina, found the ſpecific gravity of platina to be one twelfth leſs than

that of gold. It has been aſcertained by later experiments, that platina, after being purified by a long fuſion, is ſuperior in ſpecific gravity to gold.

Probably platina is not found in the mines in the ſame form in which it is brought to us; it poſſibly owes its granulated form to the waters which carry it down from the hills into the plains. It is ſometimes found in pretty conſiderable pieces: the Society of Biſcay are in poſſeſſion of a piece as large as a pigeon's egg. Platina, being found in places adjacent to gold-mines, always contains a certain quantity of that metal. As to the mercury mixed with it, this metal has been employed in extracting the gold.

Though toys made of platina have long been ſold, yet the peculiar nature of the metal was unknown. Even the workers of mines had not paid any particular attention to it; but neglected a matter which had no very beautiful aſpect, and was beſides very difficult to work. For our firſt knowledge of platina, we are indebted to a Spaniſh mathematician, Don Antonio de Ulloa, who accompanied the French academicians that were ſent on the famous journey to Peru, to aſcertain the figure of the earth. In the account of his journey, publiſhed at Madrid in the year 1748, he makes mention of this metal. Charles Wood, an Engliſh metallurgiſt, had brought ſome of it from Jamaica in the year 1741. He then examined it, and gave an account of his experiments in the Philoſophical Tranſactions for the years 1749 and 1750. At that period, the greateſt chemiſts in Europe engaged eagerly in the examination of this new metal, the ſingular properties of which promiſed to render it ſo uſeful. Scheffer, a

Swedish chemist, published an account of his experiments on platina, in the Memoirs of the Academy of Stockholm for 1752. Lewis, an English chemist, made a series of experiments, almost complete, upon this metal, which may be found in the Philosophical Transactions for the year 1754. Margraff has given a detail of his experiments on this new metal in the Memoirs of the Academy of Berlin for 1757. Most of these separate memoirs have been collected into one body by M. Morin, in a work entitled, *Platina, white gold*, or *the eighth metal, Paris* 1758. About the same time, Messrs Macquer and Baumé jointly made many important experiments on platina; an account of which has been published in the Memoirs of the Academy for the year 1758. Buffon, in the first volume of the Supplement to his Natural History, gives an account of a train of experiments on platina, made by himself, M. de Morveau, and the Count de Milly. The Baron de Sickengen likewise engaged in a series of researches on the metal of which we are now speaking; but his work has not yet been published in French. Macquer gives an extract from it in his Chemical Dictionary. M. de Lille has presented to the Academy a paper on platina. The scarcity of the metal, and the difficulties attending the treatment of it, have retarded our progress towards a complete knowledge of its properties: but of late the inquiries concerning it have been resumed with new ardour. Bergman, M. Achard, and M. de Morveau, have examined this metal in respect to several of its properties, which were before but little known.

Platina, when purified and separated by washing, picking, and muriatic acid, from the extraneous bodies which it contains, suffers no alteration of nature, only

conglomerating

conglomerating a little more by expoſure to the moſt intenſe heat. All the chemiſts who have examined the metal agree in this. Meſſrs Macquer and Baumé kept platina for a number of days expoſed to an unremitting fire in a glaſs-houſe, without producing any other alteration on its grains, but that of making them adhere ſlightly together; and they were even ſo feebly agglutinated as to be ſeparable barely by touching them. In theſe experiments, they obſerved, that platina acquired a luſtre when heated to a red white; that when very long expoſed to heat, it took a dirty grey colour; and, laſtly, that, as Margraff had aſſerted, it conſtantly increaſed in weight; which could only happen in conſequence of its being reduced in part to oxide; a change which it appears liable to ſuffer from the action of fire. Thoſe chemiſts expoſed platina to the focus of a burning glaſs: it firſt ſmoked, and gave out very red and lively ſparks; the portions of metal expoſed to the centre of the focus were next melted in about the ſpace of a minute: the melted parts were of a ſparkling white colour, and in the form of a button; they were diviſible into plates with a knife. One of theſe maſſes of melted platina being ſtruck upon ſteel, became flat, and was reduced into a plate without ſplitting or cracking: it became hard and brittle under the hammer. This fine experiment ſhows platina to be fuſible by extreme violence of fire; to be malleable like ſilver and gold; and to be liable to very little alteration from the action of fire: for in all of theſe experiments, moſt of which were performed in the open air, the platina exhibited no marks of being oxidated. M. de Morveau likewiſe effected the fuſion of platina by heating it in the wind-

furnace described by Macquer, with his reductive flux, consisting of eight parts of pounded glass, one part of calcined borax, and half a part of charcoal in powder. At present it is very easily melted in small portions, without the addition of any other substance, by heating it on a burning coal with a stream of vital air: but the globules, thus melted, are so very small, that they can answer no purpose.

Platina suffers no alteration from exposure to the air: we know not, however, what might happen, if it were kept for a long while red-hot, in contact with air: perhaps it would be oxidated, as Juncker asserts that silver and gold are, when heated in this way.

This metal suffers no alteration from water, earthy matters, salino-terrene substances, or alkalis.

Neither the sulphuric acid, however highly concentrated, the nitric, nor the muriatic acid, however strong and fuming, act at all on platina, even though assisted by ebullition. Distillation, a method which chemists have always found very effectual in promoting the action of acids on metallic matters, does not effect any solution or alteration of these mixtures; only, the sulphuric acid has been observed by Messrs Lewis and Baumé, to tarnish the colour of grains of platina. The nitric acid again improves their lustre. Margraff says, that he obtained, by distilling this acid with platina, towards the end of the operation, a little arsenic; which phænomenon has not been observed by any other chemist. The muriatic acid produces no change on platina. Margraff likewise obtained, by distilling this acid on the metal, a white sublimate, which appeared to him to be arsenic, and a reddish sublimate, the quantity

tity of which was ſo ſmall, that he could not examine its properties. All of theſe ſubſtances are evidently extraneous to platina. This metal, therefore, reſembles gold, in being but little ſubject to be affected by the action of ſimple acids; but ſtill more in being ſoluble in the oxigenated muriatic, and in the nitro-muriatic acid.

The firſt of theſe acids diſſolves platina with eaſe, and without requiring the aſſiſtance of any conſiderable heat: Fifteen or twenty degrees of heat in the atmoſphere are ſufficient to promote this ſolution: it takes place without any ſenſible effervеſcence; and, in other reſpects, perfectly reſembles the following ſolution.

The nitro-muriatic acid, which is the moſt powerful ſolvent of platina, is that conſiſting of equal parts of nitric and muriatic acid. To effect this ſolution, which is generally more difficult than that of gold, an ounce of platina muſt be put into a retort, and a pound of nitro-muriatic acid, conſiſting of the above-mentioned proportions, mixed with it: the retort muſt then be put on a ſand-bath, and a receiver fitted to it. As ſoon as the acid becomes hot, there iſſue from it ſome bubbles of nitrous gas, not in great plenty. The mixed acid acts calmly and ſlowly: this acid, however, takes at firſt a yellow colour, which changes to an orange, and becomes gradually deeper, till it be changed into a very dark brown red. When the ſolution is ended, particles of reddiſh and black ſand are found at the bottom of the retort, and are ſeparated by decanting off the liquor; the ſaturated liquor gradually depoſites ſmall irregular cryſtals of a duſky colour, which are a combination of the acid with platina. The ſolution of platina is among the higheſt coloured of metallic ſolution

lutions. Though it appears to be of a deep brown colour, yet when it is diluted in water, the fluid takes at first an orange colour, which in a short time becomes yellow, and very like the solution of gold: it communicates to animal matters a blackish brown tinge; which, however, is by no means purple. M. Baumé says, that platina, melted in the focus of a burning glass, and dissolved in aqua-regia, never takes a brown colour, like that of platina in grains; and that the solution is of a deep orange yellow.

Macquer asserts, that on evaporating the solution of platina, and suffering it to cool, crystals are obtained from it, much larger, and much more beautiful, than those which it deposites of itself when saturated. Lewis, on suffering this solution to evaporate in the open air, obtained crystals of a deep red colour, tolerably large, of an irregular form, and pretty like the acid of benzion, but thicker. Bergman describes them as having an octohædrál form. This salt is tart, but not very caustic; it melts with heat, gives out its acid, and leaves, as a residue, a dark grey oxide. The concentrated sulphuric acid produces in it a dark-coloured precipitate, which is no doubt sulphate of platina. The muriatic acid likewise produces in it, in the course of time, a yellowish sediment.

Alkalis and salino-terrene matters decompose the solution of platina, and precipitate the metal in the state of oxide. Carbonate of potash produces an orange precipitate in the solution of platina. This precipitate is not a pure oxide of platina. Messrs Macquer and Baumé have observed, that it owes its colour to its containing a certain quantity of acid. It is therefore to be considered

dered as a mixture of oxide of platina with muriate of potash, or a kind of triple salt. A proof of this opinion is, that when this precipitate is washed with hot water, the fluid acquires a colour by dissolving the salt of platina, and the residue is pure oxide of platina, of a grey colour. Fixed alkali, boiled on this precipitate, instantly deprives it of its colour, leaving an oxide of platina of a grey white pearl colour, according to the experiments of M. Baumé. That chemist made himself certain, that the precipitate of platina is soluble in alkali; for, on pouring a solution of the metal into a hot solution of carbonate of potash, he found no precipitate produced: and this solution, precipitated by fixed alkali, always retains on this account a deep colour; and platina may be easily obtained by evaporating it to dryness. Margraff discovered, that soda does not precipitate the solution of platina: but Bergman has observed, that, on putting into it a great quantity of this alkali, there is a precipitate speedily enough produced.

The alkaline Prussiates form a copious blue precipitate, which, according to M. Baumé, is owing to the iron contained in the alkali; for if the Prussiate of potash be purified by the process which that chemist describes for the purpose, from the iron which it contains, it no longer affords any more than a few particles of blue, which are owing to the metal's still retaining a small portion of iron. Bergman asserts, that an alkaline Prussiate, highly saturated and very pure, does not precipitate the solution of platina; and that this metal is the only one not liable to be precipitated

by

by this re-agent; and therefore propoſes it for ſeparating the iron which is always in union with platina.

Cauſtic ammoniac produces an orange precipitate in the ſolution of platina. This precipitate is almoſt entirely ſaline; for water diſſolves moſt part of it, taking a colour like that of the ſolution of gold. After the water has acted on this precipitate, there remains a blackiſh ſubſtance, which appears to be ferruginous. One eſſential difference between the precipitate of platina and that of gold by ammoniac, is, that the former is not fulminating like the latter.

Nut-gall, or rather the gallic acid, produces, in the ſolution of platina, a deep green precipitate, which becomes gradually pale by reſt.

All precipitates of the ſolution of platina obtained by alkaline matters, are incapable of being vitrified, and of colouring glaſs by furnace-fires. In the attempts made by Meſſrs Lewis and Baumé to accompliſh this, the platina was always reduced to grains, which were arranged in ramifications, or a kind of chequer work. Platina may be obtained in a ſort of button, by expoſing theſe precipitates to heat, together with ſome reductive fluxes, ſuch as borax, cream of tartar, glaſs, &c. Meſſrs Macquer and Baumé, melted, in five and thirty minutes, at a forge-fire, blown by two ſtrong bellows, a precipitate of platina mixed with theſe fluxes. They obtained in a hard blackiſh glaſs, like bottle-glaſs, a brilliant button of platina, which appeared to have been in fuſion. This button was not ductile: it broke into two pieces; in conſequence of which it was obſerved to be hollow within. It was nearly of the ſame hardneſs with forged iron, and made deep ſcratches in

gold,

gold, in copper, and even in iron. Notwithſtanding what we have obſerved of precipitates of platina, as not being liable to vitrify or mix with glaſs, Baumé melted them into a vitriform matter by two different proceſſes. The precipitate of platina, mixed with calcined borax and a very fuſible white glaſs, and expoſed for ſix and thirty hours to the heat of the hotteſt place of a furnace for pottery, afforded him a greeniſh glaſs, inclining to yellow, and containing no globules of reduced metal. This glaſs being treated anew with cream of tartar gypſum, and potaſh, was thoroughly melted, but contained ſmall globules of platina diſperſed through it. M. Baumé ſeparated them by waſhing, and found them to be ductile. He then, in conjunction with M. Macquer, expoſed precipitate of platina in the focus of the ſame burning-glaſs with which they had melted the metal. The precipitate emitted a very thick luminous ſmoke, which diffuſed a ſtrong ſmell of nitro-muriatic acid: it loſt its red colour, and reſumed the natural colour of platina; and it melted into a gloſſy ſparkling button: which button was an opaque vitreſcent matter, of an hyacinth colour on the ſurface, and blackiſh internally, and may be conſidered as a real glaſs of platina. It is, however, neceſſary for us to obſerve, that the ſaline matters with which it was impregnated, muſt, without doubt, have contributed to its vitrification.

The precipitate of platina does not appear to be ſoluble in ſimple acids; but it diſſolves readily in the nitro-muriatic acid, to which it communicates only an orange colour; never a brown like platina in grains.

The ſolution of platina is not precipitated by alkaline or perfect neutral ſalts; but ammoniacal muriate produces

duces in it a copious precipitate. We know not yet well what paſſes on this occaſion. It appears, that the orange colour obtained by pouring a ſolution of ammoniacal muriate into a ſolution of platina, is a true ſaline ſubſtance entirely ſoluble in water. This precipitate poſſeſſes one property of no ſmall importance, which was firſt obſerved by M. de Liſle; it melts alone, without any addition, in a good ſtrong furnace-fire, or in the fire of a common forge. The platina melted by this proceſs is a ſparkling button of conſiderable denſity and cloſeneſs of grain, but not malleable, and not liable to become ductile, unleſs when expoſed to a pretty ſtrong heat. Macquer is of opinion, that the ſame thing takes place in this inſtance of fuſion, as when grains of platina are expoſed by themſelves to the action of a ſtrong fire; and that what is affected is nothing but an agglutination of the particles ſoftened by the heat; which being much more minute than grains of platina, are brought more completely into contact with each other than thoſe grains can be; in conſequence of which, though no real fuſion take place, yet the grain of the metal is much cloſer in this than in the former caſe. It appears, however, that as platina in grains is liable to melt in a burning-glaſs, and acquires, by that means, conſiderable ductility; ſo the precipitate of this metal produced by ammoniacal muriate, being in a ſtate of extreme diviſion, may be alſo melted; and if the precipitate acquire not by fuſion the ſame ductility with platina melted by the rays of the ſun, this is perhaps owing to its ſtill retaining ſome matter which was intermixed with it when it was precipitated; but may be ſeparated from it by the action of fire.

Margraff

Margraff dissolved platina in *aqua-regia*, consisting of sixteen parts of nitric acid, with one of ammoniacal muriate. On distilling this solution to dryness, and even till the retort became red-hot, a dark red salt was sublimated, and the residue was a reddish powder. It is not known whether the solution of platina in simple *aqua-regia*, that is, *aqua-regia* consisting of nitric and muriatic acid, would afford the same sublimate by distillation.

Messrs Margraff, Baumé, and Lewis, mixed the solution of platina with solutions of the other metallic substances. From these experiments it appears, that almost all metals precipitate platina in a brick-red or a brown powder; and that, agreeably to what happens to most other metals, none of these precipitates possesses the properties of a metal. In this there is an analogy between gold and platina: with tin, however, platina does not give a purple, but a brown precipitate, inclining to red. With respect to the effects which the several metallic solutions produce on the solution of platina, we shall only observe, that solutions of bismuth and lead by the nitric acid, of iron and copper by any of the acids, and of gold by *aqua-regia*, produce, none of them, any precipitate in the solution of platina, according to Margraff: but again, solutions of arseniate of potash, of nitrate of zinc, and nitrate of silver, are capable of precipitating the solution of platina: with the first, it yields a scanty crystallized precipitate of a beautiful golden colour; with the second, an orange-red matter; and with the third, a yellow matter. These different precipitates have not been yet carefully examined; nor is it known by what decomposition they are produced.

Scarce any of the neutral ſalts acts upon platina. Margraff heated platina with ſulphate of potaſh and ſulphate of ſoda at a ſtrong fire. The ſalts were melted, but the platina remained in grains without alteration; only it communicated a faint reddiſh colour to the ſaline matters, which it was enabled to do, no doubt, by means of the iron mixed with it.

Nitre, according to the experiments of Lewis and Margraff, alters platina in a ſingular manner. No detonation takes place when a mixture of theſe two ſubſtances is caſt into a crucible; but when a mixture, conſiſting of one part of platina and two of nitre, is expoſed for a conſiderable time to an intenſe heat, as Lewis expoſed it for three days and three nights ſucceſſively, the metal takes a ruſty appearance. If this mixture be boiled in water, the fluid diſſolves the alkali, which carries with it a browniſh powder; and the platina ſeparated by this waſhing is found to be one third leſs than the original quantity. The brown powder may be ſeparated from the alkali by filtration. This powder appears to be a kind of oxide of platina, mixed with a little oxide of iron. Lewis cauſed it to take a whitiſh grey colour, by diſtilling it many times ſucceſſively with ammoniacal muriate. Margraff repeated this valuable experiment, and has added two important facts; platina combined with alkali of nitre, and diluted in a certain quantity of water, forms a jelly: A portion of the metal ſeparated from this jelly, by dilution in water and filtration, takes a black colour like pitch.— From theſe circumſtances, it appears, that the platina ſuffers in this proceſs ſome great alteration; and it is wiſhed, that theſe experiments were farther proſecuted,

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in order to determine whether by repeated oxidation with nitre, this metal might be wholly reduced to a brown powder; as alſo to aſcertain the ſtate of the platina thus oxidated.

Muriate of potaſh or ſoda, borax or earthy ſalts, produce, none of them, any alteration on platina, nor contribute in any degree to its fuſion. Ammoniacal muriate ſublimated with this metal affords a ſmall quantity of *martial flowers*, on account of the iron contained in the platina.

Chemiſts have not agreed with regard to the mutual action of arſenic and platina. Scheffer firſt gave out that arſenic acted as a flux to platina; but the experiment ſucceeded only in part with Lewis, and did not ſucceed at all with Margraff, Macquer, and M. Baumé. This experiment has been ſince repeated; and it is now eſtabliſhed as a fact, that arſenic does cauſe platina to melt very readily; and that the mixture produced by this fuſion is exceedingly brittle. When the arſenic is ſeparated by roaſting, and the perfect metal expoſed to a continued heat, the latter becomes ductile. By this proceſs, M. Achard and M. Morveau have accompliſhed the making of crucibles of platina, by melting it a ſecond time in moulds.

No attempt has yet been made to combine cobalt, nickel, or mangaueſe with platina.

This perfect metal enters readily enough into combination with biſmuth; which renders it fuſible, and the more ſo the greater the quantity of the biſmuth.— This mixture is brittle; it becomes yellow, purple, and blackiſh in the air; it cannot be cupelled without the

greateſt difficulty; the maſs has always very little ductility.

Platina eaſily melts with antimony: the product is a brittle metal with facets, from which the antimony may be ſeparated by the action of fire, but which ſtill retains, whatever means may be uſed for its ſeparation, ſo much of the antimony as is ſufficient to deſtroy the gravity and ductility of the platina.

Zinc renders platina very fuſible, and combines very eaſily with it; the mixture is brittle, and reſiſts the file: it inclines to blue in colour, when the platina is more copious than the zinc. Theſe two metallic matters are ſeparable by the action of fire, which volatizes the zinc; platina, however, always retains a little of it.

Platina does not combine with mercury; and though triturated together for hours, theſe two metallic matters cannot be formed into an amalgam. It is alſo known, that in America mercury is employed to ſeparate platina from gold. Various intermedia, ſuch as water, which Meſſrs Lewis and Baumé made uſe of, and nitro-muriatic acid, which M. Scheffer employed, contribute nothing to the union of platina with mercury. It reſembles iron in this property, as alſo in colour and hardneſs.

Platina readily combines with tin. The mixture is very fuſible, and melts into a flowing liquid. It is ſo brittle as to break even by a blow, when the two metals are united in equal parts. When tin is in the proportion of twelve or more parts to one of the platina, the mixed metal is then ſufficiently ductile; but its grain is coarſe, and it becomes yellow in the air. The platina diminiſhes the ductility of the tin in an amazing degree, and it does not appear that any advantage can be deri-

ved

red from this mixture. However, when well polished, it remains long in the air without suffering alteration. Lewis, to whom we owe most of our knowledge concerning the mixtures of platina, oxidated the metal, and dissolved it in muriatic acid by means of the tin.

Lead and platina combine very well by fusion; but a stronger fire is requisite to melt them than to melt the foregoing mixture. The platina destroys the ductility of the lead. From the combination of these two metals there results a mixed metal, nearly of a purple colour, more or less brittle according to the proportions of the platina, striated and granulated in its fracture, and liable to alter very readily in the air. Cupellation of lead was one of the most important experiments to be made on platina; for this was the only operation that could be expected to separate from it such extraneous matters as it might contain. Lewis, and several other chemists, in vain attempted to cupel platina in common cupelling furnaces, whatever the degree of the heat employed in those furnaces. On account of the excess of the lead, it is vitrified and absorbed in the beginning of the operation; but the platina soon becomes fixed, and the progress of the operation stops; the perfect metal remains in union with a portion of the lead, and is without ductility. Messrs Macquer, and Baumé effected the complete cupellation of platina, by exposing an ounce of this metal with two ounces of lead to the heat of the hottest place of the porcelain-furnace at Seves. The wood fire that they kindled in it burned for fifty hours uninterruptedly. At the end of that time the platina lay flat upon the cupel: its upper surface was dark and shrivelled, and was easily separable from the [illegible]; its

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under ſurface was brilliant; and what is of moſt importance, it was now ſufficiently malleable. These chemiſts aſcertained, by every poſſible means, the platina to be very pure, and unmixed with lead. M. de Morveau likewiſe ſucceeded in cupelling a mixture of a dram of platina with two drams of lead in Macquer's wind-furnace. This operation, which was four times repeated, laſted eleven hours. M. de Morveau obtained a button of platina, not adheſive, uniform, coloured like tin, ſomewhat rough, weighing exactly a dram, and not ſubject to the attraction of the magnet. This is therefore a convenient proceſs, by which platina may be melted into plates that may be wrought in the forge; and of conſequence made into various utenſils of great value for their hardneſs and unalterability. M. Baumé likewiſe obſerved it to poſſeſs this valuable property, that different pieces of it may be ſoldered and wrought together like iron, without the intervention of a third metal. After heating two pieces of platina that had been cupelled in the furnace of Seves to a white red, he put the one upon the other, and ſtruck them with a hammer; and by this management the two pieces were as ſufficiently and ſolidly ſoldered as any two pieces of iron could have been. It is not neceſſary that we ſhould inſiſt long on this experiment, to ſhow what advantages the arts may derive from it.

Lewis could not obtain a mixture of forged iron and platina. A mixed metal of this kind would poſſeſs at once the hardneſs of tempered ſteel, and a conſiderable degree of ductility; it would not at leaſt be ſo brittle as ſteel. The Engliſh chemiſt, whom we have cited, melted a mixture of caſt iron and platina. The alloy was

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so hard that the file could make no impression upon it: it had little ductility; but when red-hot it broke with a smooth fracture.

Platina communicates hardness to copper, and melts with it easily enough. This mixture is ductile when the proportion of the copper is three or four times that of the platina. It takes a fine polish, and is not liable to be tarnished in the course of ten years.

Platina destroys in part the ductility of silver, increases its hardness, and tarnishes its colour. The mixture is very difficult to melt. The two metals are separable by fusion and rest. Lewis observed, that the silver melted with platina is dashed with a kind of explosion against the sides of the vessel. This phænomenon seems to be effected solely by the silver; for M. d'Arcet saw that metal burst bowls of porcelain, in which it was inclosed, and spring out of those vessels in consequence of the action of the fire upon it.

A very strong heat is requisite to make platina combine properly with gold. It greatly alters the colour of that metal, at least if its quantity be not very small; for instance, a forty-seventh part of platina, and all proportions under that, produce but little alteration on the colour of gold. Platina scarce diminishes the ductility of gold; it is even one of those metals which have the least influence on gold this way. The gravity of platina being greater than that of gold, might be an encouragement to fraud; and the Spanish ministry have therefore prohibited the exportation of the metal. However, since chemical methods of distinguishing when gold is alloyed with platina have been discovered, these fears are now vain; and it is much to be wished, that pla-

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tina were permitted to be an article of commerce, that ~~so~~ we might obtain the uſe of a new metal, which promiſes to be ſo ſerviceable.

The ſolution of ammoniacal muriate poſſeſſes, as we have obſerved, the property of precipitating platina. When, therefore, gold is ſuſpected to be alloyed with platina, a ſolution of it in *aqua-regia* may be aſſayed with a ſolution of ammoniacal muriate. If it contain any platina, however little, an orange or reddiſh precipitate will be produced: if there is no precipitate produced, this circumſtance is a proof that the gold contains no platina. If the valuable properties of platina ſhould one day render it more ſcarce and more eſteemed than gold, neither will we then be in danger of having alloys of gold with platina impoſed upon us for pure platina; for a ſolution of ſulphate of iron, which poſſeſſes the property of precipitating a ſolution of gold without affecting platina, might be uſed as a teſt to prevent ſuch impoſition. A plate of tin immerſed into a ſolution of platina, alloyed with gold, would likewiſe detect the preſence of the latter metal, by becoming coated with a purple precipitate; whereas platina by itſelf gives it only a dirty brown colour, inclining to red. Beſides, the precipitate of platina does not colour glaſs; whereas the precipitate of gold gives it a purple colour.

All theſe properties of platina which we have examined prove it to be a peculiar metal. Its poſſeſſing in ſo low a degree the properties of ductility and fuſibility, which has been conſidered by ſome perſons as a ſtrong objection againſt this opinion, is not ſufficient to juſtify the refuſing it that character which we have aſcribed to it: for perhaps the difference between the fuſibility of platina

platina and that of forged iron, is not ſo conſiderable as the difference between the fuſibility of forged iron and that of lead: and its inductility may be conſidered as owing to its having never yet been completely melted. With reſpect to the opinion of thoſe philoſophers who think platina a natural alloy of gold with iron, however ingenious and ſatisfactory it may appear, it cannot be admitted till ſuch time as platina ſhall be ſeparated by an exact analyſis into theſe two metals, and till it be better imitated than at preſent by an artificial mixture of gold with iron. Laſtly, Macquer has urged a very ſtrong objection againſt this laſt opinion, by obſerving, that the more thoroughly platina is purified from iron, the more remote does it appear in its exterior characteriſtics and properties from the nature of gold.

It may be eaſily conceived with what advantages the uſe of this precious metal in commerce would be attended, as it poſſeſſes, with the durability of gold, nearly the hardneſs of iron, and is proof againſt the action of the moſt violent fire, and the moſt concentrated acids. It would, doubtleſs, be of the higheſt utility both to chemiſtry and to the arts.

The denſity and opacity of platina render it valuable for the conſtruction of optical inſtruments. The Abbé Rochon has conſtructed a mirror of this metal, the effect of which greatly ſurpaſſes that of the mirrors made of ſteel and other metals. Like other metallic mirrors, it reflects but a ſingle image; but is at the ſame time as unchangeable as the mirrors of glaſs. H.

CHAP. XXIII.

Genus VI. *Bitumens in general* *.

BITUMENS are combuſtible matters, either ſolid, ſoft, or fluid, of a ſtrong, acrid, aromatic ſmell, and apparently of a much more compound nature than any of the bodies belonging to the mineral kingdom which we have yet examined. They are found either in ſtrata in the bowels of the earth, or dropping from rocks, or ſwimming on the ſurface of waters. They generally burn with a rapid flame when heated in contact with air, like thoſe matters formed by the organs of animals and vegetables, which are called *oils*. They do not admit of being ſo exactly analyſed as earthy, ſaline, or metallic matters; for the action of fire alters them in a ſingular manner, extracting from them principles, which, as they are volatilized, re-act on each other. In this reſpect,

* The reader may here recollect, that we divided combuſtible mineral matters into five genera; diamond, hydrogenous gas, ſulphur, metals, and bitumens.

ſpect, there is an analogy between bitumens and vegetable and animal ſubſtances. They afford, by diſtillation, an odorate water phlegm, more or leſs coloured and ſaline; an acid generally concrete; ſometimes ammoniac; and oils, which, though at firſt light, become more and more thick and coloured, as the diſtillation is continued, and the ſtrength of the fire increaſed. After this analyſis, there remains a coal of a greater or a leſs bulk, denſe, light, porous, brilliant, or compact, according to the particular nature of the bitumen. This analyſis is a proof that theſe inflammable bodies have originated from animal or vegetable matters; as we ſhall relate more at large when we give the hiſtory of their properties.

Bitumens ſuffer ſome alterations from light; when fluid, their colour is rendered deeper, and their ſmell modified in tranſparent veſſels. The air renders them thicker by a gradual evaporation of the moiſture which they contain; and the drier the atmoſphere, ſo much the ſpeedier is this evaporation. Their odorous principle, or ſpiritus rector, is at the ſame time gradually diſſipated; and from fluid they become by degrees tenacious and ſolid. But this latter alteration requires a long ſeries of years.

When bitumens are boiled in water, the water does not diſſolve them, but extracts their ſpiritus rector, and afterwards exhales that odour which is peculiar to them. It would therefore appear, that water has a greater affinity with their odorous principle than the oily matter of the bitumen; and perhaps theſe bodies might thus be entirely deprived of ſmell.

No experiments have been made to determine in

what manner the falino-terrene fubftances act upon bitumens. Both lime and pure alkalis, however, appear capable of combining with thefe combuftible matters, and forming with them compounds foluble in water, which are called *foaps*.

We know not in what manner the mineral acids are capable of acting on bitumens. Probably they would either diffolve or burn them like oils, according to the ftate of concentration in which they happened to be.

Neither has the action of neutral falts, hydrogenous gas, fulphur, or metals, on bitumens, been examined; and the chemical properties of thefe bodies are in general but very little known. This is an unbeaten path; and very ufeful difcoveries might here be made.

Naturalifts have been at much more pains in ftudying the origin and formation of bitumens, than chemifts in analyfing them. Several different opinions have been entertained on this head. Some have thought combuftible bodies to belong properly to the mineral kingdom, and to hold in it the fame rank which oils and refins hold among organic matters. But this fancied analogy, however plaufible, does not agree with facts; for we know of no fubftance in the mineral kingdom of an oily nature. And that opinion which afcribes the origin of bitumens to vegetable matters buried under ground, and altered by the action of mineral acids, has been much more generally received than the former. Every fact, indeed, concerning bitumens, concurs to prove, that they have been produced from organic matters. Near them are found a great many matters

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ſtill retaining an organical form. Beſides, their chemical properties are thoſe of ſubſtances formed by the action of vital powers; and they have been imitated to a certain degree by the combination of oils with concentrated ſulphuric acid. In the chemical hiſtory of vegetable matters, we ſhall ſee, that this acid brought into contact with eſſential oils, renders them hard and black, and communicates to them a ſtrong pungent ſmell like that of bitumens. But are theſe bodies formed ſolely from vegetables buried under ground, as has been aſſerted by moſt naturaliſts? Do animal matters, in the ſame ſituation, never contribute to the formation of bitumens? One objection which may be urged againſt the opinion that repreſents bitumens as originating ſolely from particular vegetable bodies, is the great diſproportion between the maſſes of bitumen found in the earth, and the wood or trees found near them, and ſtill more the trifling quantity of oily matters contained in thoſe vegetable ſubſtances. And farther, the abundance of theſe combuſtible bodies, in places where ſcarce any remains of vegetable matters appear, but the exuviæ of animals are found in heaps above the bitumens, leads us to think, that theſe latter organic beings have contributed greatly, perhaps more than vegetables, to the formation of certain bituminous ſubſtances. We may likewiſe obſerve, that the ſucceſſive ſtrata, in which ſome continuous maſſes of bitumen are found arranged in the interior parts of the globe, indicate thoſe maſſes to have been depoſited ſlowly, and by water; and that the date of their formation correſponds to the period in which ſuch immenſe maſſes of ſhells, and other marine bodies, have been formed by the ſea. They have therefore been in

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a fluid ſtate, and have become hard in the courſe of time, in conſequence of being expoſed to the action of ſaline or other ſubſtances, abounding in the interior parts of the earth. Such is the opinion which M. Parmentier, Member of the College of Pharmacy, has embraced concerning the origin of mineral coal, in a Memoir which he read before that Society at the opening of their courſe of lectures. The oils and fats of marine animals appear therefore to be part of the materials which Nature employs in the formation of certain bitumens: and there are others again, the origin of which is evidently from vegetables, and which have been produced from reſins or eſſential oils, buried and altered in the earth.

The number of bitumens is very conſiderable. Naturaliſts have arranged them under various genera. Conſidered chemically, they merit rather to be conſidered as ſo many ſpecies; for the ſame chemical characteriſtics are common to them all. Some of them are liquid; others of a ſoft conſiſtency: there are others ſolid, and among theſe ſome ſo hard as to be ſuſceptible of poliſh: others friable. We know of five ſpecies, conſiderably diſtinct from one another. Theſe are amber, the aſphaltes or bitumen of Judæa, jet, pit-coal, and petroleum; and we are to give their hiſtory. Ambergris we do not conſider as a bitumen but, as an animal product.

CHAP.

CHAP. XIV.

Species I. *Of Amber, and its Acid.*

THIS ſubſtance is, in external appearance, one of the moſt beautiful of bituminous matters: it exiſts in irregular fragments of a yellow or brown colour, either tranſparent or opaque, and compoſed of layers or ſcales. It takes a very fine poliſh. After being rubbed for ſome time, it becomes electric, and attracts ſtraws. The ancients, who knew amber to poſſeſs this property, gave it the name of *electrum*, and hence the word *electricity*.

The conſiſtency of this bitumen is pretty hard, nearly equal to that of certain ſtones; which has induced ſeveral authors, particularly Hartman, a naturaliſt who lived about the end of the laſt century, to rank it among precious ſtones. It is, however, brittle and friable.—When pulverized, it diffuſes an agreeable enough ſmell. It is often found to contain inſects in a good ſtate of preſervation; a circumſtance which proves that it has been in a liquid ſtate, and in that ſtate has incloſed theſe bodies.

bodies. It is uſually buried under ground, at various depths; it is found under coloured ſand, in ſmall incoherent maſſes, on beds of pyritous earth: above it, is found wood containing a blackiſh bituminous matter. From theſe circumſtances, it is thought to be formed from a reſinous ſubſtance, altered by the ſulphuric acid of the pyrites. It alſo floats on ſea-coaſts. It is gathered on the ſhores of the Baltic in Ducal Pruſſia. The hills of Provence, near the town of Siſteron, the marquiſate of Ancona, and the duchy of Spoletto in Italy; Sicily, Poland, Sweden, and various other countries, likewiſe afford this ſubſtance. This bituminous ſubſtance is diſtinguiſhed into a good many varieties, by its colour, contexture, tranſparency, or opacity. Wallerius reduces them to the following

Varieties.

1. White tranſparent amber.
2. Pale yellow tranſparent amber.
3. Citron yellow tranſparent amber.
4. Tranſparent amber of a golden yellow colour. *Chryſo-electrum* of the ancients.
5. Dark red tranſparent amber.
6. White opaque amber. *Lucelectrum.*
7. Yellow opaque amber.
8. Brown opaque amber.
9. Amber coloured green or blue by extraneous matters.
10. Veined.

Were we to take notice of all the accidental appearances which are obſerved in the interior parts of pieces of amber, we might extend theſe varieties to a much more conſiderable

considerable number. But, in regard to the price demanded for pieces of amber, on account of their size, their transparency, and their containing insects in a fine state of preservation, it is proper to warn people that they may not be imposed upon; as many persons know how to render it transparent, or colour it at pleasure, as well as to soften it to a degree that extraneous bodies may be introduced into it. Wallerius informs us, that gold-coloured amber always owes its transparency to nature; and that amber made transparent by art is always of a pale colour.

Although it be highly probable, that this bitumen originates from resinous vegetable matters; yet several naturalists have entertained different opinions concerning its formation. Some have thought it to be urine of certain quadrupeds, congealed and hardened; others have imagined it a juice of the earth, extracted and carried off by the sea, which being driven by the waters on the shore, is there dried and hardened by the rays of the sun. This class of naturalists call it a peculiar mineral juice. Such was the opinion of an ancient naturalist of the name of Philemon, quoted by Pliny. It has been in modern times revived by George Agricola. Frederick Hoffman thought it to consist of a light oil, separated by heat from bituminous wood, and thickened with the acid of vitriol. This opinion of Hoffman's, however, cannot be admitted: it is not easy to imagine how an oil separated in the bowels of the earth could happen to contain animals that are known to live only on the surface. Till of late, amber was thought to be a resinous juice, which dropped at first in a fluid state from certain trees: this juice, it was thought, having been,

been, by some convulsion of the earth, buried under ground, had been there hardened, and impregnated with saline mineral vapours. But there is no appearance of its having been altered by concentrated acids; for experience shows, that such acids would have blackened it, and reduced it to a carbonaceous state. Pliny thought amber to be nothing but the resin of the pine-tree condensed by cold. M. Girtanner thinks it to be a vegetable oil concreted by the acid of the ants. The *formica rufa* of Linnæus is, according to this author, the species which prepares it. These insects inhabit old forests of fir-trees, where there is fossile amber found, which is ductile, like liquid wax, but becomes dry in the air.

A considerable degree of heat is necessary to liquify amber: it becomes soft, and swells a good deal. When heated in contact with air, it takes fire, and diffuses a very thick and strong-smelling smoke. Its flame is yellowish, variegated with green and blue. After its combustion there remains a sparkling black coal, which affords, by incineration, a very small quantity of brown earth. Bourdelin, in his Memoir on Amber (*Academy*, 1742), relates, that he obtained only eighteen grains of this earth from two pounds of amber burnt in a roasting pot. Half a pound of the same bitumen, burnt and calcined in a crucible, afforded, in a second operation, twelve grains of earthy residue; from which, by means of the magnet, he extracted iron.

Amber distilled in a retort, by a fire gradually applied, gives at first a phlegm which takes a red colour, and is plainly of an acid nature. This acid spirit retains a strong smell of amber; there passes next a volatile acid salt, which crystallizes in the neck of the retort

into ſmall white or yellowiſh needles ; next after this ſalt, there comes a white light oil of a very lively ſmell. This oil gradually takes a colour as the fire becomes ſtronger, and at length becomes brown, blackiſh, thick, and viſcid, like empyreumatic oils. While theſe two oils are paſſing, there is a certain quantity of volatile ſalt ſublimated, which becomes gradually more and more coloured. After the operation, there remains in the retort a black maſs fixed on its bottom, brittle, and ſimilar to the bitumen of Judæa. George Agricola made this obſervation three centuries ago, on the reſidue of diſtilled amber. When the operation is conducted with a moderate fire, judiciouſly applied, and the quantity of the amber not inconſiderable, theſe products may be obtained ſeparately by changing the receiver. They are commonly received all in one receiver, and afterwards rectified by a moderate heat. The acid loſes its colour in part by this rectification. The oil, the reaſon of which becoming black towards the end of the operation, is becauſe it carries with it a portion of carbonaceous matter, and becauſe the acid re-acts on its principles,—may be rendered very white and very light by repeated diſtillation. Rouelle, the elder, has given a very good proceſs for obtaining it in this ſtate by one operation. Put the oil with water into a glaſs alembic, and diſtil it by the heat of boiling water ; the pureſt portion, being the only part of the oil volatile at ſuch a degree of heat, on account of its levity, paſſes with the water, and is collected above it. To preſerve it in this ſtate, it muſt be put up in ſtone-veſſels ; for in glaſs-veſſels, the rays of light which paſs through that matter, give it, in a certain time, a yellow, or even a brown colour.

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This analyſis proves amber to conſiſt of a great quantity of oil rendered concrete by an acid. It contains likewiſe a very ſmall quantity of earth the nature of which has not been yet examined, and a few particles of iron.

The oil of amber appears to be much of the ſame nature with eſſential oils. It is equally volatile, and has the ſame ſmell. It is very inflammable; and appears to be fit for forming ſoaps with alkalis.

The volatile ſalt of amber was for ſome time conſidered as an alkaline ſalt. Glaſer, Le Fevre, Charas, and John-Maurice Hoffman, profeſſor at Altdorf, were of this opinion. Barchuſen, and Bouldoc the father, both in the laſt century, were the firſt who aſcertained the nature of this ſalt to be acid. Their diſcovery has been unanimouſly received by ſucceeding chemiſts; who have not agreed, however, concerning the particular nature of that acid. Frederick Hoffman, becauſe amber is found in Pruſſia under ſtrata of matters among which pyrites are copiouſly intermixed, has inferred its ſalt to be vitriolic acid. Neumann appears to be of the ſame opinion. Bourdelin, in the Memoir above quoted, relates ſeveral experiments, by which he ſought to aſcertain the nature of this ſalt. He firſt obſerves, that the ſalt of amber, extracted by diſtillation, however white and pure it may appear, always contains an oily matter; to this oily ſubſtance, no doubt, it owes its ſmell, and that kind of combuſtibility which it conſtantly exhibits when caſt on burning coals. He attempted by various means to ſeparate that ſubſtance. We ſhall have occaſion to ſee, when we come to examine the nature and properties of alkohol, that *it* could not ſerve his purpoſe.

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He succeeded no better by digesting fixed alkali over amber, with a view to separate from it this oily matter; the alkali only dissolved a little of the bitumen, and acquired a saltish lixivial taste, like that of sea-salt. Lastly, the best means which Bourdelin could find for combining the acid of amber entirely purified from oily matters with fixed alkali, was to detonize a mixture, consisting of two parts of nitre, with one of the bitumen. The residue, after this detonation, he lixiviated with distilled water. The lixivium was of an amber colour: it produced, in the solution of silver, a white curdled precipitate; in the solution of mercury, a precipitate of the same colour. It decomposed, in like manner, several other metallic solutions; but Bourdelin considered only these two precipitations as conclusive facts. He understood them as indicating the acid of amber to be the same with that of marine salt; for these phænomena are precisely the same with those which the acid of marine salt produces in the nitric solutions of mercury and silver. The lixivium of the residue which remained after the detonation of amber with nitre, being evaporated in the air, afforded a mucilaginous matter, in the middle of which oblong square, crystals were by degrees deposited; which, by their form, their saltish taste, their decrepitation on burning coals, and still more their effervescence, which was considerable, and the smell of muriatic acid which exhaled from them, when concentrated sulphuric acid was poured upon them, indicated, in his opinion, that they consisted of muriatic acid, with a base of nitre. Notwithstanding this analysis, which, considering the time which Bourdelin made his experiments, is very accurate, the

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chemists who have since examined the salt of amber have not found it to bear any resemblance to the muriatic acid. Bergman, who seems to have adopted this opinion, gives the following account of the properties and the elective affinities of this salt. The succinic acid or acid of amber, extracted by distillation, and purified by repeated solutions and crystallizations, forms, with potash and ammoniac, crystallizable and deliquescent neutral salts. With soda, it affords a salt which does not attract the moisture of the atmosphere: with barytes and lime, it forms salts that are scarce soluble: with magnesia, a thick gum-like matter. It dissolves metallic oxides; and the succinates produced by these solutions are mostly crystallizable and permanent.

Barytes, lime, and magnesia, according to him, separate the acid of amber from alkalis. Barytes decomposes succinates of lime and magnesia; and lime-water precipitates magnesia from its combination with this acid.

The chemical properties of this bitumen have been no farther examined. We know not even how the acids would act upon it. Frederick Hoffman affirms, that it may be entirely dissolved in a lixivium of caustic alkali, and in sulphuric acid. We know, too, that the essential oil of amber combines with caustic ammoniac, and forms with it, simply by mixture and shaking, a sort of liquid soap, of a milk-white colour, and of a very pungent smell, known in pharmacy by the name of *Eau de luce:* and lastly, this same oil is known to dissolve sulphur by the heat of a sand-bath, thus composing a medicine, called *succinated balsam of sulphur.*

Amber is used in medicine as an antispasmodic: it has

has been recommended for hysteric and hypochondriac cases, a suppression of the *menses*, gonorrhœa, fluor albus, &c. It is made use of after being washed with warm water, and levigated to a fine powder. It is used in fortifying and resolvent fumigations, by throwing the powder on a hot brick, and directing the smoke to the place upon which you wish it to act. The volatile spirit and the salt of amber are considered as incisive, cordial, and antiseptic; they are also administered as powerful diuretics. Oil of amber is applied both externally and internally for the same purposes as amber itself: it is administered in smaller dozes, on account of its acting with more energy. The succinated balsam of sulphur is given in dozes of a few drops in certain drinks, or mixed with other substances in pills, and is successful in pituitous affections, or defluxions of the breast and kidneys, &c. A syrup, called *syrup of amber*, is made up of spirit of amber and opium, and is successfully used as a calming, an anodyne, and an antispasmodic medicine. *Eau de luce* is prepared by pouring a few drops of oil of amber into a phial full of caustic ammoniac, and shaking the mixture till it take a milk-white colour. It has been long used in fainting-fits as a powerful stimulant: it is put to the nostrils, and it then stimulates the nerves; and, by the sneezing which it excites, the fluids are again put into motion, and the patient restored.

The most beautiful pieces of amber are cut and polished into vessels, heads of canes, necklaces, bracelets, snuff-boxes, &c. But this species of toys is no longer valued among us, since diamonds and cut stones have

been

been known and brought into uſe. They are ſent, however, to Perſia and China, and to other foreign countries, where they are ſtill valued as the greateſt curioſities. Wallerius ſays, that the moſt tranſparent pieces may be uſed for microſcopes, burning-glaſſes, priſms, &c. It is affirmed, that the late King of Pruſſia was poſſeſſed of an amber burning-glaſs a foot in diameter; and that in the cabinet of the Duke of Tuſcany there is a column of amber ten feet high, and of a moſt beautiful luſtre. Two pieces of this bituminous ſubſtance may be joined together, by dipping them into a ſolution of potaſh, heating them, and applying them to each other.

CHAP.

CHAP. XXV.

Species II. *Of Asphaltus.*

ASPHALTUS, or *bitumen of Judea*, called alſo *funeral gum*, *amber of Sodom*, *mountain-pitch*, *balm of mummies*, &c. is a black bituminous ſubſtance, ponderous, ſolid, and conſiderably brilliant. It breaks eaſily, and its fracture is vitreous. A thin plate of this bitumen appears red between the eye and the light. Aſphaltus, when cold, has no ſmell; when rubbed, it emits a faint ſmell. It is found on the waters of the lake Aſphaltites, or the Dead Sea, in Judea, near which ſtood the ancient cities of Sodom and Gomorrha. The inhabitants of the adjacent country, finding the ſmell of the bitumen, which gathers on the waters of that lake, troubleſome, and the bitumen itſelf a profitable article of commerce, collect and expoſe it to ſale. Lemery, in his Dictionary of Drugs, ſays, that aſphaltus ſweats like liquid pitch out of the earth covered by the Dead Sea; and riſing above the waters, is there condenſed by the heat of the ſun, and the action of a ſalt which abounds in thoſe waters. It is alſo found on many lakes in China.

The asphaltus of commerce, M. Valmont de Bomare tells us, is obtained from the mines of Daunemore, and especially in the principality of Neufchatel and Wallengin. According to that naturalist, it is of two colours, either blackish or greyish. But such asphaltus is far from being pure; it seems to be only earth hardened, and intermixed with bitumen which has penetrated through it.

Naturalists are divided concerning the origin of asphaltus, as well as concerning the other bitumens. Some think it a mineral product, formed of an acid united in the interior parts of the earth, with some fat matter. Others think it a resinous vegetable matter, that has been buried under ground, and altered by mineral acids. The most general and probable opinion is, that it has been produced in the same way as amber, and is actually nothing but amber altered by the action of subterraneous fire. The ground of this opinion is, that amber, when melted and deprived of a part of its oil, becomes black, dry, brittle, and in all respects like asphaltus. But it can be finally established only by a comparative analysis of this residue of amber and asphaltus. Asphaltus has not yet been examined with such exactness as will allow us to presume on the analogy between them.

Asphaltus, when exposed to fire, becomes liquid, swells, and burns with a thick flame and smoke; the smell of which is strong, acrid, and disagreeable. By distillation, it affords a coloured oil, like brown petroleum, and an acid phlegm.

Asphaltus is used by the Arabians and Indians in the

ſame way as pitch for coating their veſſels. It enters into the compoſition of the black varniſhes which we get from China, and of thoſe artificial fires which burn on water. The Egyptians uſed it in embalming dead bodies; but it was employed for that purpoſe only by the poor, who could not afford to purchaſe dearer antiſeptic matters. Wallerius aſſerts, that the merchants prepare a ſort of aſphaltus of thick pitch, or by mixing and melting pitch with aſphaltus from Judea. But the fraud may be detected by means of alcohol, which entirely diſſolves pitch, but produces no change on aſphaltus, only taking itſelf from it a pale yellow colour.

CHAP. XXVI.

Species III. *Of Jet.*

JET, in Latin *gagas*, called by Pliny *black amber*, by Strabo, &c. *pangetis*, is a black bituminous ſubſtance, compact, hard like ſome ſtones, brilliant and vitreous in its fracture, and ſuſceptible of a fine poliſh. After being rubbed for ſome time, it attracts light bodies, and, like amber, appears to be electric. It has no ſmell: when heated, it acquires a ſmell nearly the ſame with that of the bitumen of Judea.

Jet is found in France, in Provence, and in the county of Foix. There is alſo a quarry of it which is wrought at Beleſtat in the Pyrenees. It is found too in Sweden, in Germany, and in Ireland. The quarries of jet are in ſtrata; they likewiſe contain pyrites and pit-coal, and moſt of the other bitumens.

This bitumen, when expoſed to a ſtrong heat, becomes ſoft and melts; it burns with a fœtid odour. By diſtillation, it affords oil and an acid liquor.

Of

Of the ſeveral opinions which have been advanced ıcerning the formation of jet, the moſt probable is ıt which repreſents it as aſphaltus condenſed and harıed by length of time. It has been adopted by the rned Wallerius.

Jet is uſed for mourning toys. At Wirtemberg it is ·ought into bracelets, buttons, boxes, &c.

CHAP.

CHAP. XXVII.

Species IV. *Of Pit-coal.*

THE name of *foſſil-coal*, *pit-coal*, *ſtone-coal*, *lithantrax*, &c. is given to a black bituminous matter, foliated, either gliſtering or dull, brittle, and inferior in conſiſtency and purity to the bitumens which we have been deſcribing.

This bitumen derives its name from its combuſtibility, and the uſe to which it is in many countries applied. It is found in the interior parts of the earth, under ſtones of various degrees of hardneſs, and under aluminous and pyritous ſchiſti. Theſe ſchiſti always bear impreſſions of vegetables belonging to the ferntribe, which have been obſerved by Bernard de Juſſieu to be moſtly exotics. Pit-coal is ſometimes nearer to, ſometimes more remote from, the ſurface of the earth. Its diſpoſition is always in horizontal or inclined layers; ofteneſt in inclined. The beds or ſtrata which it compoſes differ from each other in conſiſtency, *colour*, gravity, &c. Over this bitumen, ſtrata

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of foſſil-ſhells and madrepores, varying in extent, are often obſerved; a circumſtance which has led ſome moderns, particularly M. Parmentier, to think that it has been formed in the ſea by the depoſition and alteration of the oily or fat matters of marine animals. Moſt naturaliſts think it the reſidue of wood depoſited in the ground, and altered by acids.

Quarries of foſſil-coal are wrought like mines of metal by digging into them pits and galleries, and hewing down the coal with a ſort of pick-axes. The colliers are often in danger of loſing their lives by the elaſtic fluids diſengaged. This mephitis, which they call *choak damp*, puts out their lights, and ſeems to be carbonic acid gas. There likewiſe gathers in theſe mines a kind of inflammable gas, the effects of which are very noxious, and which ſometimes produces very dangerous exploſions.

Foſſil-coal is very plentiful in nature. It is found in England, Scotland, Ireland, Hainault, the territory of Liege, Sweden, Bohemia, Saxony, &c. Several provinces of France afford great quantities, particularly Burgundy, the diſtrict of Lyons, Forez, Auvergne, Normandy, &c.

Foſſil-coal is diſtinguiſhed by its hardneſs, or friability into ſtone-coal or earth-coal. The manner of its burning, and the phænomena which it exhibits during combuſtion, afford the beſt characteriſtics for diſtinguiſhing it into different ſpecies. Wallerius arranges foſſil-coals, conſidered in this point of view, under three ſpecies. 1. The ſcaly coal, which remains black after combuſtion. 2. The compact foliated coal, which affords, after being burnt, a ſpongy matter like ſcoriæ. 3. Fibrous pit-

coal,

coal, resembling wood, which is reduced to ashes by combustion.

This bitumen, when heated in contact with a burning body and air, takes fire; the more slowly, and with the greater difficulty, the more ponderous and compact it is: when it has once taken fire, it diffuses a lively lasting heat, and burns long before being consumed. It may be quenched and burnt again, for a number of times successively. The inflammable matter contained in it appears to be very dense, and in a manner fixed in some other incombustible substance, which opposes its combustion. It exhales as it burns a peculiar odour; which, however, is no way sulphureous, if the coal be very pure, and contain no pyritous matter. The combustion of this bitumen seems very analogous to that of organic matters, as it may be stopped and afterwards renewed. The most volatile part of the oily combustible matter contained in pit-coal is indeed burnt and dissipated when it is first exposed to the action of heat; and if, after the whole of that principle is dissipated, the combustion be stopped, the bitumen retains only the most fixed and the least inflammable part of its oil, in a truly carbonaceous state, and combined with an earthy base. It is by a process of this nature that the English prepare their *coaks*, which are nothing but pit-coals deprived by the action of fire of the fluid part of their oil.

We may easily observe what happens in this operation, by heating this bitumen in close vessels, and in a distillatory apparatus. It affords in this way an alkaline phlegm, concrete ammoniacal carbonate, and an oil which, as the distillation proceeds, takes a deeper colour, and

and becomes more ponderous. There paſſes at the ſame time a large quantity of an elaſtic inflammable fluid, which is commonly thought to be oil in vapours, but is properly hydrogenous gas, mixed with azotic gas, with carbonaceous matter diſſolved in it, and with carbonic acid gas. There remains in the retort a ſcorified carbonaceous matter, which is ſtill ſuſceptible of combuſtion, and is the ſame with the Engliſh *coak*. Obſerving carefully the action of fire on pure pit-coal, we perceive the coal to be firſt ſoftened, and in a manner half melted. Some ſpecies of pit-coal do not experience this fuſion, or rather ſoftening, from the action of caloric. Theſe ſpecies would ſeem to contain leſs oil than thoſe which ſoften in the fire: but the laſt are the moſt frequent, and the beſt. The diſtinction of the pit-coal into different kinds, is far from being ſo exact as it will be made hereafter. M. Faujas has thrown ſome new light on this ſubject, in a Diſſertation, publiſhed by him a few months ſince, on pit-coal. But as this property might render it unſuitable for the melting of ores, it muſt be deprived of it before it be applied to that purpoſe. After taking from it the principle which renders liable to ſoften, that is, the oil which it contains in great abundance, and thus reducing it to a ſtate nearly the ſame with that of vegetable coal, it then becomes ſuitable for the fuſion of ores. Let us not forget to obſerve, that the ammonaic which pit-coal affords in ſuch conſiderable quantity, affords an argument in favour of that opinion which repreſents this bitumen as produced from animal matters; for, as we ſhall hereafter ſee, bodies belonging to the animal kingdom always afford this ſalt when diſtilled. This analyſis is performed in the

great way in various places in England; and the several products are collected in a peculiar distillatory apparatus. The oil is used for pitch; the ammoniac is used in the composition of ammoniacal muriate; and the residue is a very good *couk*. M. Faujas de Saint Fond has imported this useful art into France; and the trials which he has made in the king's garden have succeeded very well in the small way: We have as yet no establishment for carrying it on in the great way *.

Pit-coal is highly useful in countries destitute of wood. It is used as a combustible matter; and the dangerous effects which have been ascribed to it are quite imaginary. The sulphureous vapour which it has been said to diffuse has no existence; for chemists have universally found, by the most exact analysis, that pure mineral coal contains not an atom of sulphur. From this we see the ignorance and imposture of some people who have pretended to give processes for purifying coals of sulphur. Another consideration which should induce us to make as much use as possible of coals in France is, that such enormous quantities of charcoal are consumed in the working of ores, that our wood is likely to fail one day or another; it is especially in works of that kind we should try the use of pit-coal, as the English have long done. It is already beginning to be used in various manufactories among us; and in the famous founderies of iron at Creusot, near Montcenis in Burgundy, there is a great instance of its application to these purposes, highly worthy of imitation.

Purified

* The English reader will here recollect the patriotic exertions of the Earl of Dundonald to establish works of this kind in Britain. H.

Purified pit-coal is nothing but that which has been deprived of its oil by the action of fire. This sort of coal burns without smoke, without softening, and without diffusing any strong smell; in a word, it is a true *coak*; and is, on account of these properties, preferred for fires in rooms.

Another inconvenience, beside the copious dark smoke proceeding from it, which attends the burning of pit-coal, is, that the copious and rapid stream of air requisite to maintain it in combustion, carries before it, and volatilizes, a part of the ashes. But both these inconveniences may be in a great measure remedied by a judicious construction of chimneys; so that the current of air, and whatever matters mix with it, may be entirely carried up, and discharged in the air, and no part of it returned and dispersed through the room.

This combustible matter will in France be applied with most advantage for the service of arts and manufactures of all kinds; in consequence of which, wood may be greatly saved for kitchen and room fires, and for building.

CHAP.

CHAP. XXVIII.

Species V. *Of Petroleum.*

THE name of *petroleum*, or *oil of ſtone*, has been given to a liquid bitumenous ſubſtance which runs between ſtones upon beds of rocks, or in various places on the ſurface of the earth. This oil is of various degrees of levity, ſmell, conſiſtency, and inflammability. Authors take notice of a great many varieties of it. The lighteſt, the moſt tranſparent, and the moſt inflammable *petroleum*, they have diſtinguiſhed by the name of *naphtha*. *Petroleum*, properly ſo called, is a liquid bitumen, ſomewhat thick, and of a deep brown colour: mineral pitch, again, is a black bitumen, thick, ſcarce liquid, tenacious, and adheſive to the fingers: The following varieties have been deſcribed by Wallerius, and ſeveral other naturaliſts.

Varieties.

1. White naphtha.
2. Red naphtha.

3. Green or dark naphtha.
4. Petroleum mixed with earth.
5. Petroleum trickling through ſtones.
6. Petroleum ſwimming on waters.
7. Mineral pitch, or *maltha*.
8. Piſſaſphaltus. It is of a middle conſiſtency, between that of common petroleum and that of aſphaltus, or bitumen of Judea.

The ſeveral ſorts of naphtha are found in Italy, in the duchy of Modena, and on Mount Chiaro, about twelve leagues from Placentia. Kempfer, in his *Amœnitates Exoticæ*, relates, that great quantities of it are gathered in many places in Perſia. Petroleum runs in Sicily, and in many places of Italy; in France, at the village of Gabian, in Languedoc; in Alſace, at Neufchatel in Switzerland; in Scotland, &c. Piſſaſphaltus and mineral pitch were formerly obtained from Babylon, in the building of the walls of which they had been employed; from Raguſa in Greece, and from the pond of Samoſata, the capital of Comagena in Syria. It is at preſent obtained from the principality of Neufchatel and Wallengin, from the Well de la Page, a league from Clermont-Ferrand in Auvergne, and from various other places.

With regard to theſe ſeveral varieties, it is to be obſerved, that they ſeem to be all produced from one common origin, and to be but different modifications of the ſame ſubſtance. Moſt naturaliſts and chemiſts aſcribe the formation of petrolea to the decompoſition of ſolid bitumens by the action of ſubterraneous fires. Naphtha,

they obſerve, appears to be the light oil which is first diſengaged by fire: that which follows after it, having colour and conſiſtency, forms the ſeveral ſorts of petroleum: And, laſtly, petrolea, united with earthy ſubſtances, or altered by acids, acquire the characteriſtics of mineral pitch, or piſſaſphaltus. The phænomena of the diſtillation of amber favour this opinion: It affords actually a ſort of naphtha, and a petroleum too, of a higher or a lighter brown colour, according to the degree of heat employed, and the length of time ſpent in the operation. Laſtly, They obſerve, that nature often affords all the different ſorts of petroleum in the ſame place, from the lighteſt naphtha to mineral pitch. Such are the fluid bitumens from Mount Feſtin, in the duchy of Modena. Although this opinion be very probable, yet other authors think petroleum an oily mineral combination, formed by the ſulphuric acid with ſome fat matters. But even ſuch a combination muſt ſtill be allowed to originate from organic beings; as fat matters are always formed by thoſe beings.

The chemical properties of petroleum have not yet been examined. We know only, that naphtha is very volatile, and ſo combuſtible, that it takes fire when brought near any burning body; it even appears by its volatility to attract the flame. From brown petroleum there is obtained an acid phlegm, and an oil which at the firſt reſembles naphtha, but acquires a colour as the diſtillation proceeds. There remains in the retort a thick matter like piſſaſphaltus, which by greater activity of fire may be rendered dry and brittle like aſphaltus, and entirely reduced to a carbonaceous ſtate. Alkalis ſcarce act upon petroleum: the ſulphuric acid co-

lours

nd thickens it; the nitric acid kindles it, in the ıanner as eſſential oils: it eaſily diſſolves ſulphur; loured by metallic oxides; and it combines with and with the help of heat ſoftens and diſſolves a f it.

ſeveral kinds of petroleum are uſed for various es in the countries in which they abound. Kemp- s us, they are uſed in Perſia, to give light, and in lamps with wicks. They may alſo be uſed for on fires. Lehman ſays, that for this end the a is poured on a few handfuls of earth, and l with paper; it takes fire, and burns with great r, but diffuſes a ſmoke in great abundance, which to all bodies that come in its way, and has a very eable ſmell. Petroleum is likewiſe thought to part of the Greek fire. Thick petroleum makes very ſolid and durable mortar. By the decoction aſphaltus with water, an oil is obtained, which is or pitching veſſels.

ly, Some phyſicians have deſcribed petroleum ucceſs in diſorders affecting the muſcles, palſy, eſs, &c. by rubbing the ſkin with it, or expoſing ts ſmoke. Vanhelmont thought friction with pe- n, an excellent cure for frozen limbs, and re- ends it as a good preſervative againſt the effects l.

PART THIRD.

The Vegetable Kingdom.

CHAP. I.

Of the Structure of Vegetables.

VEGETABLES are organized beings, confined to the surface of the earth, without sensibility or power of motion. They are known by their appearance, and the conformation of their parts. They are distinguished from minerals, by receiving their nourishment internally, and elaborating the juices to which they owe their growth. They display to our observation phænomena which depend on their organization, and are called *functions*; the chief of these is that of reproducing themselves by seeds, or *ova*, like animals.

Vegetables differ from one another, 1. In size; they are divided into trees, shrubs, herbs, mosses, &c. 2. In local

local situation; some grow in dry grounds, others thrive in a moist soil; some, again, in sand, clay, water, on the surfaces of stones, or on other vegetables, &c. 3. In smell, taste, colour, &c. 4. In duration; plants either live for a number of years, or only for one year, or are produced and die twice a-year, &c. 5. In the uses to which they are applicable; they are used either as aliments, or as medicines. A great many of them are made use of in the arts, for dyeing, &c. others for adorning gardens, &c.

Vegetables, considered with respect to the external conformation of their parts, consist of six parts or organs, destined each to a peculiar function: these parts are the root, the stem, the leaf, the flower, the fruit, and the seed. These, again, differ in different plants, in form, contexture, bulk, number, colour, hardness, taste, &c.

1. The root is concealed in the ground, in water, or in the bark of some other vegetable. It is either tuberous, or fibrous, or bulbous. Its direction is either perpendicular or horizontal. Both its form and consistency are subject to great varieties. Botanists divide the roots of plants into many species; which distinctions they sometimes make use of to determine the specific characters of the plants themselves.

2. The stem proceeds from the root, and supports the other parts of the plant. It is either solid or hollow, ligneous or herbaceous, round, square, triangular, or with two very acute angles, &c. The stem consists of wood and bark. The wood is distinguished into wood properly so called, and sap: the bark consists of the epidermis, the vesicular part or pulp, and the cor-

tical ſtrata or inner rind. The ſtem divides into branches, the ſtructure of which is preciſely the ſame with its ſtructure. This part, too, is liable to ſuch diverſities as enable botaniſts to eſtabliſh upon it the diſtinctive characters of ſpecies, and ſtill oftener of varieties.

3. The leaves of vegetables are extremely various: A. in form; they are oval, round, linear, ſagittated, haſtate, oblong, elliptical, cuneiform, &c.: B. in their poſition on the ſtem; they are ſeſſile, petiolate, oppoſite, alternate, ſtellate, perfoliate, vaginal, &c.: C. in their margins; they are uniform, dentate, crenate, ſerrate, repand, undulated, laciniated, truncated: D. in ſimplicity or compoſition; compound leaves are formed by the inſertion of foliolæ, or ſmaller leaves; they are then either digitate or conjugate, with either an even or an odd number of leaves: E. in place or ſituation; they are radical, cauline, or floral: F. in colour, ſmell, taſte, conſiſtency, &c.; they ſeem deſigned to abſorb elaſtic fluids from the atmoſphere, and to pour others into it, according to circumſtances.

4. The flowers are thoſe parts which Nature has deſigned to contain the organs of generation, and to preſerve them from injury till the fecundation be accompliſhed; at which time they fall off. A flower conſiſts of two parts; the exterior, deſigned to cover and protect the interior; the uſe of which is to re-produce the plant. The former comprehends the calix and the corolla; the calix is exterior, and of a green colour.

Linnæus divides the calices of plants into ſeven ſpecies; namely, the perianthium, the ſpartha or ſheath, the huſk, the involucrum, the amentum or catkin, the

calyptra

calyptra or veil, and the volva. The corolla is the coloured part, commonly called the *flower*: it is either a single piece, and monopetalous; or consisting of several pieces, polypetalous. Tournefort's system is founded on the corolla. The pieces of the corolla are called *petals*. The organs inclosed, and often entirely concealed in the corolla, are the stamina and pistils or styles. The stamina are the male or fecundating parts; and are almost always more numerous than the pistils. They consist of the filament and the anthera. The anthera, placed at the extremity of the filament, is a small bag, containing fecundating powder. The pistil stands in the middle of the stamina; it is sometimes on another flower, or even on another plant: this circumstance has caused some plants to be distinguished into male and female. The pistil consists of three parts; the inferior part, or ovarium, which contains the embryo; and is called in Latin *germen*; the filament, which rises out of the ovarium, or style; and its extremity, which is more or less dilated, and is called *stigma*. The sexual system of Linnæus is founded on the number, and the relative positions of the stamina, and the pistils. M. de Jussieu has formed a system from the insertion of the stamina, above or under the germen, &c.

5. Flowers are succeeded by fruits. Botanists distinguish fruits into seven species; the capsule; the siliqua; the legumen; the conseptaculum, which becomes dry; fruits having kernels; fruits having pippins and berries, which remain succulent. The purpose of these organs is to inclose the seeds, and to protect them from suffering by the action of external bodies.

6. The feeds of plants differ greatly in form, magnitude, appendices, &c. The feed contains the plumula, or fmall plant, the radicula, and the cotyledons. There are two of thefe latter in moft vegetables; yet many families of plants have but one cotyledon. This part is to the grain, what the yellow and white of an egg are to the embryo bird; it contains a fubftance intended for nutriment to the young plant during the germination. Befides, the cotyledons of many feeds contain flefhy and farinaceous bodies, &c.

Vegetables, confidered as to their internal ftructure, contain five fpecies of veffels, or organs, which exift through all their parts; 1. The common veffels which convey the fap. Thefe are placed in the middle of plants and trees; they rife perpendicularly, but bend laterally, fo as to form fmall vacancies between them. 2. The peculiar veffels which fecrete and convey the juices peculiar to each vegetable, oils, refins, gums, &c. Thefe are placed under the bark; they are often dilated into cavities, or refervoirs; they feem to be excretory ducts. 3. The tracheæ, through which the air that vegetables take in from the atmofphere, circulates. When a young and green branch is broken, thefe may be obferved, and known from their fpiral form, refembling a cork-fcrew. They are often full of fap. 4. The utricles, which are formed of fmall bags, containing the pith, and frequently colouring matter. They are placed in the middle of the ftem. 5. The veficular tiffue, exhibiting a feries of fmall cells, leading horizontally from the pith, croffing the fap-veffels, filling up the vacuities among them, and fpreading over the epidermis, where they form

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a soft covering like the skins of animals. The vesicular tissue of vegetables seems to correspond to the cellular membrane of animals.

All parts of vegetables consist of an assemblage of these five kinds of vessels; which are, each of them, more or fewer in number, dilated, contracted, &c. On this diversity, in point of number and disposition, depend the differences in the form and texture of the roots, stems, leaves, &c. of plants.

Malphigi, Grew, and Duhamel, are the three naturalists who have studied the anatomy of vegetables with the greatest success; and their works will be consulted with the greatest advantage, concerning the internal structure of the several parts of vegetable bodies.

CHAP.

CHAP. II.

Of the Natural Philosophy of Vegetables.

ALL these organs of vegetables, of which we have given the above brief account, are designed for the performance of the various motions called *functions*. These functions are,

1. The motion of the fluids, which is a sort of circulation.

2. The alterations or changes produced on those fluids, which are effected in their secretion.

3. The growth of the vegetable, and the developement of its parts by nutrition.

4. The exhalation of the several fluids elaborated by the organs of vegetables, and the receiving of several principles from the atmosphere by the same organs.

5. The action of air, and the employment of that fluid in the vessels of vegetables.

6. The motion performed by some of their parts.

7.

7. That sort of sensibility by which they court the contact of bodies that may be useful to them, such as light, &c.

8. Lastly, The several phænomena, by which plants are generated, and species reproduced. Let us consider each of these functions more particularly.

The principal fluid in vegetables, which is called the *sap*, is contained in certain ducts, which are known by the name of *common vessels*. These vessels, situated in the centre of the stem, and under the bark, extend from the root all the way to the leaves and flowers. The sap which they convey is a colourless fluid, more or less insipid in taste, and intended, like the blood of animals, to be separated into different juices, for the nourishment and sustenance of the various organs. In spring it flows very copiously, causing the plant to display leaves and flowers. By applying ligatures, and by all the phænomena of vegetation, it has been proved, we think in a satisfactory manner, that the sap ascends from the root through the stem and the branches. We are not so certain whether it be true, as some naturalists have thought, that it descends again towards the root. The existence of those valves, which some botanists have represented as belonging to the common vessels of plants, has not been demonstrated; not at least unless we give the name to certain filaments or hairs with which Tournefort and Duhamel have observed their interior sides to be lined. There is a vast difference between this irregular motion and the circulation of the fluids in animals.

The sap being conveyed into the utricles, and thence into the proper vessels, is there elaborated in a peculiar manner. By this elaboration it is wrought into different

fluids,

fluids, saccharine, oily, mucilaginous, which are discharged by an organic excretion; and of which the evacuation seems to be an advantage to the vegetable, as it does not appear to suffer even from a considerable loss of these matters. This alteration of the fluids, which may be distinctly observed as it takes place in several of the organs, in the nectarium, for instance, at the extremity of the pistil, in the pulp of fruits, at the base of the calices, and of many of the leaves, is entirely effected by a function similar to that which in animals bears the name of *secretion*. Guettard has carried this analogy so far as to describe glands of various forms, at the bases of the leaves of fruit-trees, and towards the inner extremity of the petals of certain flowers. This secretion separates the odorous principle, the colouring matter, the combustible substance, &c.; but it differs from animal secretion, as animal secretion is entirely owing to the organization of the glands which elaborate the animal fluids: whereas in vegetables, the juices conveyed through the common vessels, are in the proper vessels more exposed to the contact of air and light, and the action of heat; and their situation renders them liable to pass, by the operation of these agents, through a process of fermentation, by which only they can be altered.

The sap in the cavities of the utricles and the vesicular tissue, becomes thick, and acquires more or less consistency. In consequence of this alteration, it adheres to the sides of the fibres, and incorporates with them gradually, so as to increase their dimensions. Such is the mechanism by which vegetables are nourished and grow, and unfold their parts. It bears a great resemblance to the

the nutrition of animals. The vesicular tissue of vegetables, and the cellular membrane of animals, are formed with a similar structure, and intended to serve similar purposes. They pass in the same manner through all the organs of the bodies to which they respectively belong; they establish a direct communication among these organs; and both may be said to be the seats of nutrition.

Philosophical botanists have long been convinced, that plants exhale effluvia, from their surfaces, which are diffused through the air. The odorate spirit of leaves and flowers forms round vegetables, an atmosphere which affects the senses in a lively manner; and which, as has been observed with regard to the fraxinella, the contact of a burning body will sometimes set on fire. This effluvia appears to be an inflammable gas of a peculiar nature. Mankind have also learned from fatal experience, that some vegetables exhale vapours, noxious to such animals as approach them. The walnut, the yew, and many other trees, natives of warm climates, are of this kind.

M. Ingenhousz has discovered by experiment, that the leaves of all plants, when exposed to the sun and to light, pour into the atmosphere an invisible fluid, which is vital air of the same qualities with that obtained from oxide of manganese, mercury, &c. But in the shade they no longer exert such a property; instead of vital air, they give out carbonic acid gas, when deprived of the contact of light. This valuable discovery, which was first communicated to the world by Dr Priestley, shows vegetables to possess a property that was not before attributed to them, and to be capable of purifying

and

and renovating the air, by pouring into it a portion of that vivifying fluid which is constantly consumed by combustion, respiration, &c. But if vegetables are continually diffusing vaporous fluids through the atmosphere, produced by the last processes of vegetation; they likewise absorb several of the principles of the atmosphere. The experiments of Bonnet show, that the under surface of the leaves absorbs moisture from the dew. Dr Priestley has proved, by his researches, that vegetables absorb the gazeous residues of combustion and respiration; for vegetation is more speedy and vigorous in air altered by these phænomena. Exhalation and inhalation are therefore much more considerable and important phænomena of the vegetable kingdom, than they were known to be before the modern discoveries. It even appears, that the water absorbed by the under part of the leaves is decomposed by their organs, its hydrogenous gas absorbed, and its oxigene converted into the vital air which is disengaged from the upper surfaces of the leaves. The rays of the sun contribute greatly to this decomposition; for it does not take place in the shade. The water being then not decomposed, but absorbed entire, renders the plants white, insipid, soft, and in a word *ætiolated;* and in such cases, much less colouring, combustible, or oily matter, is formed, than when the plant is exposed to the action of light.

The gases absorbed by vegetables are conveyed through all their organs by vessels known under the name of *tracheæ*, which in their use and structure bear a resemblance to those of insects and worms. But the conveyance of this fluid is not the only purpose for which these tracheæ are intended. They are observed to be filled

illed with ſap in the ſeaſon when that fluid flows in greateſt abundance; a circumſtance which diſtinguiſhes hem widely from thoſe organs of reſpiration which be-ong to ſo great a number of animals, and are ſo eſſen-ially neceſſary. From the theory of reſpiration which we have laid down in the hiſtory of air, it is eaſy to ex-plain why vegetables poſſeſs not free heat in a degree of temperature ſuperior to that of the atmoſphere.

Several parts of vegetables have, no doubt, an inter-nal principle of motion. In ſome plants this motion is ſo conſiderable as to be obſervable by the eye. Such is the motion of the ſenſitive plant, of the ſtamina of the Indian fig, of pellitory, &c. This motion ſeems to cor-reſpond to that function of animal organs which is call-ed *irritability;* for it is effected by the action of a ſti-mulus, and by peculiar organs, which are by ſome bo-taniſts compared to the muſcular fibres.

Can we deny plants to poſſeſs a ſort of ſenſibility, when we ſee them turn their leaves and flowers towards the ſun; when we obſerve, that, if encloſed in boxes of wood, with glaſs on one ſide, or perforated with an open hole, or ſimply thinner on that ſide than on the other, they conſtantly turn towards the tranſparent body, or the aperture through which light is permitted to enter, or the ſide which, being thinner, is nearer to that fluid than the other? Or, is this appearance of ſenſibility ra-ther to be conſidered as an effect of the power of affinity, of the tendency of vegetables to combine with light? It has been fully proved, that, either by percuſſion or com-bination, this ſubſtance produces in plants the proper-ties of colour, taſte, and combuſtibility; in the ſhade, even the talleſt plants are white, inſipid, aqueous, and deſtitute

destitute of any inflammable principle: but, again, vegetables exposed to the rays of the sun, in the torrid climates of the south, are very high coloured, contain bitter and resinous parts, and are very combustible. However strong this affinity be allowed to be, yet it is hard to imagine how it could excite such a motion in the branches and leaves of vegetables. We must therefore grant them a peculiar sensation, a sort of feeling very different indeed from that of animals, by which they are enabled to distinguish and prefer such situations as are most exposed to the light.

The methods which nature uses for the reproduction of species of vegetables are strongly analogous to those by which the generations of animals are perpetuated. The greatest number of the species of plants are propagated by sexual coition. The labours of the celebrated Linnæus have discovered a striking resemblance between the organs designed for this purpose in these two classes of organic beings. The stamina of plants correspond to the genital parts of male animals, and the pistils consist of three parts, which bear an equal resemblance to the same organs of female animals. The embryo is developed by the action of the fecundating powder, without which a new individual could not be produced from it; agreeably to what is daily observed of birds. But besides this analogy, which it would be needless to trace farther, as vegetables are of a much simpler structure than animals, and their parts consist all of the same organs, any of them is capable of producing a new individual similar to that which it belonged. This is the reason of the reproduction of plants by means of scions or slips, as

well as of the alteration of their fluids by grafting, whether natural or artificial. Here, therefore, is another analogy between vegetables and that clafs of animals which are reproduced by divifion into pieces, as polypi, cruftaceous infects, certain worms, &c.

All thefe functions of vegetables, which bear fo ftriking an analogy to thofe of animals, are liable to alterations, by which the vegetable is brought into a difeafed ftate. Thefe difeafes to which plants are liable, depend commonly either on fuperfluity or defect of fap, as well as on the bad qualities which the fap may happen to acquire; and they bear, therefore, no fmall refemblance to thofe with which animals are affected. Their caufes, fymptoms, and cure, come under the general principles of medicine; and form a branch of agricultural knowledge, in which, it muft be confeffed, little progrefs has yet been made; but which may be greatly advanced by following the directions of fome celebrated modern writers on the fubject.

CHAP. III.

Of Juices and Extracts.

THE fluids contained in vegetables are of two kinds, the common and the proper juices. The firſt of theſe conſtitute the ſap, which is found in all plants. This fluid ſeems to perform the ſame functions in vegetable, which the blood does in animal bodies. It is contained in the common veſſels: It runs naturally from their ſurfaces; but may be extracted in greater abundance by inciſion. The ſap is not an aqueous fluid, but contains ſalts, extracts, and mucilages. When a certain quantity of it is wanted, in order to an examination of its properties, or for medical uſes, the plant is brayed in a mortar, and ſqueezed through a linen cloth: if the plant do not readily yield its juice, it is put into a preſs.

Succulent vegetables give out their juice by ſimple expreſſion. Thoſe whoſe juices are viſcid, or not very copious, muſt be treated with water to ſwell and dilute them; ſuch are borage and the dry aromatic plants. This

This fluid, when extracted by the force of pressure, is found to contain a portion of the solids of the vegetable, which were bruised with the pestil: it must then be purified. Juices of plants are purified, 1. Simply by rest, or by filtration, when they are very fluid: in this way, for instance, are the juices of purslain and the house-leek purified. 2. By the white of eggs, which collects the impure parts by coagulation; it is used with borage, nettles, &c. 3. By the simple application of heat, which coagulates and precipitates the parenchyma: M. Baumé recommends this as the best way for purifying those vegetable juices which contain volatile principles, such as that of cochlearia, cresses, &c. The phial containing the juice is immersed in boiling water, care having been taken to cover it with a piece of paper perforated with a hole; when the juice becomes pure, it is taken out; it is then immersed in cold water, and the juice filtrated. 4. By alcohol, which coagulates the feculent part. 5. By vegetable acids, which the London Pharmacopœia prescribes for the juices of cruciform plants.

There are matters dissolved in the juices of plants, which, when separated from the aqueous vehicle, form what is called in pharmacy the *extract*. These matters are distinguished into three species, mucilaginous, saponaceous, and gum-resinous extracts.

Those are called *mucilaginous extracts* which dissolve easily in water, are scarce soluble in alcohol, and undergo spirituous fermentation; such is the rob of the gooseberry, which is prepared by evaporating the juice.

Saponaceous extracts dissolve in water, ar partly so-

luble in alcohol, and rather mould than paſs into a ſtate of ſpirituous fermentation. Such is the juice of borage when reduced to an extract. Theſe are extracts properly ſo called.

Gum-reſins are ſoluble both in water and in alcohol. They are inflammable, as containing a reſinous principle, and are not liable to ſuffer any alteration from air. The concentrated juice of wild cucumber, called *elaterium*, is of this ſort. Inciſions are made in the fruit of this plant; and the juice ſqueezed out, ſuffered to clarify of itſelf, and evaporated to dryneſs on a water-bath.

Theſe three different ſorts of extracts are prepared in the great way for commerce, by the evaporation of the juice of various plants. Of theſe, among others, are,

1. The juice of acacia; which is prepared in Egypt by pounding the fruit of that tree, preſſing out the juice, and evaporating it by the ſun: the juice of acacia, from Germany, is prepared from the juice of ſloes by a ſimilar proceſs.

2. That of hypociſtis, which is prepared like the above, from the fruits of this paraſitical plant.

3. Opium, a medicine of great importance, the nature of which ſhould be very well known. It is extracted from the white poppy in Perſia, &c. There flows out, by inciſions made in the green capſules of that plant, a white juice, which is dried into brown tears; this is the true opium. The opium which is commonly ſold, is prepared by firſt ſoaking the capſules in water, and then ſqueezing them; this juice is dried, and formed into flat circular cakes, covered with leaves, and

mixed

mixed with a good deal of impurities. To purify it, it is diſſolved by the help of heat, with as ſmall a quantity of water as poſſible; the liquor is filtrated or ſtrained by ſtrong preſſure, and evaporated on a balneum mariæ. This is the extract of opium. This ſubſtance contains a ſaponaceous extract, a reſin, a ſolid eſſential oil, an odorous principle, which is poiſonous and narcacotic, an eſſential ſalt, and a glutinous matter. As the odorous, poiſonous, and narcotic principle, is often noxious, attempts have been made to obtain the extract of opium without that principle. M. Baumé, who has examined this medicine with much care, volatilized that principle, together with the eſſential oil, and in conſequence of that, ſeparated the reſin by digeſtion, for ſix months. Bucquet has diſcovered, that this extract may be obtained in ſuch a ſtate as to be ſedative, and not narcotic, by diſſolving opium in cold water, and evaporating the ſolution in a balneum mariæ. Lorry, who has made ſome very valuable experiments on this matter, has diſcovered, that fermented opium affords by diſtillation a ſedative water which has no poiſonous qualities, and has preſcribed it with great ſucceſs. He obſerves, that the odorous principle of this medicine cannot be deſtroyed by this proceſs.

To obtain the extracts of dry ligneous plants, we muſt employ maceration, infuſion, or decoction in water, according to the particular ſtate and nature of the matter, from which the extract is deſired; maceration is often ſufficient. Odorous plants can only be treated by infuſion. Decoction carries off too much of their ſubſtance, and ſeparates the reſinous part: it forms an highly concentrated thick fluid, which becomes turbid

by cooling. Infusion will be sufficient in any case. Such is the opinion of the greatest chemists and the most celebrated physicians.

By water, various products can be extracted from several plants. Thus juniper-berries afford with water a mucilaginous extract; quinquina affords a saponaceous extract, which is obtained in small transparent scales, of a saline appearance, if the solution be evaporated in broad flat vessels; rhubarb affords in the same manner a gum-resinous substance.

The chemical extract, properly so called, or the saponaceous extract, was thought to be a compound of oil with fixed vegetable alkali. It was justly observed, however, that the extracts prepared in pharmacy are far from being all of the same nature; they are mixed with mucilage, essential salt, saccharine juice, and resin. For this reason, Rouelle, with a view to throw new light on this part of medical chemistry, has distinguished them, as above mentioned, into three genera. But the pure extract, reckoned among the immediate principles of vegetables, is to be considered as a compound differing from the others, and possessed of peculiar properties. I have just discovered, that this principle is not a soap; that it possesses the property of absorbing oxigene from the atmosphere; of becoming insoluble in water, and of assuming the characters of a concrete oil. These are the properties by which I ascertain the presence of this substance, and distinguish it from all the other immediate principles of vegetables.

There are extracts prepared in the great way for commerce by water. Such are,

1. The juice of liquorice, which is yellow by the firſt nfuſion, and black by a powerful decoction. The black uice is burnt, and actually contains coal. It is purified by melting it in water, filtering and evaporating the ſolution, which is rendered aromatic by the addition of eſſential oil, of anniſeed, cinnamon, &c.

2. The cachou, which is obtained in the Eaſt Indies, from an infuſion of the ſeed of a certain palm-tree, called the *areca*. This ſolution is evaporated, and the matter obtained is formed into broad cakes. The cachou is purified for medical purpoſes by ſolution in water and evaporation. It is ſeaſoned with aromatics like liquorice-juice.

Among the extracts which are prepared for medical purpoſes, Rouelle has taken particular notice of thoſe mixed with reſin, by the name of *extracto-reſinous*, or *reſino-extractive matter*.

Extracto-reſinous matter does not burn till after it be dried: it ſeems to contain more extract, properly ſo called, than reſin. *Reſino-extractive matter* burns much better than the former: it ſeems to contain a greater proportion of reſin than of the extractive matter. This diſtinction proves theſe two ſpecies to be nothing but mixtures of extract in various proportions with a reſinous principle. They are not, therefore, extracts properly ſo called; and the name can be with propriety applied only to the ſaponaceous matter; which is therefore the ſubſtance whoſe properties we ought to examine.

The pure extract differs from thoſe above mentioned. Taking all its properties together, we may conſider it

as a dry ſolid ſubſtance, of a brown red colour, tranſparent, not capable of burning by itſelf, but which exhales a good deal of ſmoke, and is found to contain more or leſs eſſential ſalt. Its taſte is almoſt always bitter, it affords by diſtillation an inſipid phlegm; expoſed to a moderate fire, the phlegm by degrees takes a colour, and becomes of an alkaline nature, which is obſerved of elaterium, the extract of borage, &c. The ammoniac of the product, is formed by the heat: there paſſes next a little empyreumatic oil; the coal is light, contains potaſh, and almoſt always neutral ſalts. The extract, when expoſed to the air, acquires a kind of moulding over its ſurface, and attracts moiſture; and the ſalts mixed with it, cryſtallize and ſeparate from the extractive part. They are often entirely altered and decompoſed on this occaſion. It diſſolves in water, and is then like a ſtrong infuſion. Acids decompoſe this ſolution like ſoaps. Metallic ſolutions likewiſe precipitate it; and the ſubſtances are, on this occaſion, mutually decompoſed. Theſe properties were thought ſufficient to make extract be looked upon as a kind of ſoap: they are moſtly owing, however, to the attraction of this ſubſtance for oxigene, and to its abſorption of this principle. Extract, therefore, properly ſo called, muſt henceforth be conſidered as an organic compound of hydrogene, carbone, and a little azote, poſſeſſing a ſtrong attraction for oxigene, which it abſorbs from every ſubſtance that contains it, and afterwards paſſes into an oily concrete ſtate.

Extracts are employed in medicine as aperitives, diſcuſſives, diuretics, ſtomachics, and almoſt always with great ſucceſs.

CHAP.

CHAP. IV.

Of the essential Salts of Vegetables; and of those in particular which are analagous to Mineral Salts.

THE saline substances held in solution in the juices of plants, or in water in which they have been infused, are called their *essential salts*. They are extracted by suffering these fluids to cool, after they have been evaporated to the consistency of a syrup. As these salts are impregnated with extracts and fat matters, they need to be purified with lime and the white of eggs. When the salts are acid, lime must not be used, as it would neutralize them, but pure white clay in powder. After this first extraction, they are still very impure. They are dissolved in distilled water, and repeatedly crystallized till they become white. This process can be employed only on those essential salts of vegetables which are crystallizable; but there have been some vegetable salts discovered which are not crystallizable, and which, on account of their mixture or combination with other principles, cannot be extracted by such a simple process. In giving an account of the salts contained

in

vegetables, or at leaſt obtained from them, we ſhall diſtinguiſh them into the following ſix genera.

The firſt genus comprehends all ſuch vegetable ſalts as are analogous to thoſe with which we are acquainted in the mineral kingdom.

The ſecond conſiſts of the pure acid ſalts of plants.

In the third we ſhall rank acid ſalts combined with a certain quantity of potaſh, under the generic name of *acidulæ*.

To the fourth genus we may refer ſuch as are formed by the action of the nitric acid on ſome vegetable matter.

The fifth may contain ſuch as owe their formation to heat.

Laſtly, Under the ſixth we include vegetable acids produced by a particular fermentation.

Firſt Genus of Vegetable Salts. Salts analogous to thoſe of the Mineral Kingdom.

THE firſt genus of the eſſential ſalts of vegetables comprehends neutral ſalts extracted from their juices by evaporation, which are analogous to thoſe of the mineral kingdom. The principal ſpecies of theſe ſalts are, 1. Fixed alkalis in combination with carbonic acid, which are obtained from almoſt all plants, by macerating them in acids, as has been ſhown by Margraff and Rouelle the younger : potaſh is moſt commonly obtained ; ſoda exiſts in ſome marine plants. 2. Sulphate of potaſh, in millefoil, in old borage, in aſtringent and aromatic plants, in ſpurge flax, and in the mark of olives. 3. Sulphate of ſoda, from tamariſk, and from rotten

rotten wood. 4. Nitre, from borage, turnsole, tobacco, &c. 5. Muriate of potash, and muriate of soda, from marine plants. 6. Sulphate of lime, discovered by Model in rhubarb. The existence of the last salt is doubtful; for Scheele suspects that what Model took for sulphate of lime was only calcareous oxalate.

By an accurate analysis of a greater number of plants, many other salts might no doubt be found in vegetables, resembling mineral salts. It was also thought that ammoniacal carbonate existed ready formed in some cruciform plants; because those plants, when distilled, afforded, by the first impression of the heat, a phlegm, in which there was a little of this salt dissolved. The ancient chemists, on this account, called those plants *animal plants*. But Rouelle the younger has shown, that the salt is not ready formed in the plant, but is produced in consequence of the re-action of the principles of the plant occasioned by heat. M. Baumé has represented this volatile principle of cruciform plants, as being nothing but sulphur. The ammonaic obtained from those plants has been fully proved by M. Berthollet, to proceed from the combination of the hydrogenous part of the oil with the azote contained in the vegetable.

Naturalists have been of different opinions concerning the mineral salts found in plants. Some think the salts to be conveyed from the earth into the vegetable by water, without alteration. Others think them to be formed by the act of vegetation. One thing certain is, that two very different plants, such as borage and millefoil, growing on the same soil, afford each its peculiar acid; borage, nitre, and millefoil, sulphate of potash. This

doubtful

doubtful queſtion might be determined by a ſingle experiment; of which much has been ſaid, but which has never been performed with ſufficient exactneſs. The experiment is, to raiſe, from a previouſly lixiviated earth, plants affording a kind of ſalt, like nitre, and to water them with water impregnated with muriate of ſoda, or ſome other ſalt. If they ſhould be ſtill found to afford nitre, and not muriate of ſoda, it might be inferred, that ſalt does not paſs from the earth into the plant unaltered, but that the proper ſalt is formed in the plant by the functions of vegetation. Whatever may be the reſult of this experiment, it will be proved, that a number of the ſalts which we examined in the mineral kingdom are immediately formed in vegetables.

CHAP.

CHAP. V.

Of the second Genus of Essential Salts, or of the Pure Acids of Vegetables.

IN the second genus of essential vegetable salts, we rank those acids which are entirely formed in plants, and are extracted from them pure by very simple processes. There are five acids of this genus, the citric, the gallic, the malic, and the benzoic.

§ 1. *Of the Citric Acid.*

WE give the name of *citric acid* to the pure acid which Scheele obtained from lemon-juice.

Chemists formerly, without attending to the peculiar characteristic of this acid juice, compared it to that of tartar; and at that period all vegetable acids were thought to be of the same nature. Attempts have been made to concentrate and purify the acid juice of the lemon

mon and the orange, in order to preserve them for long voyages. The juice of the former of these fruits has such an acid taste, and produces such an effectual alteration on blue colours, that there can be no doubt entertained concerning its nature. M. de Morveau has found the specific gravity of this juice to be to that of distilled water as 1,860 to 1.

When this juice is kept for some time, it acquires a disagreeable taste, and is covered over with a mouldiness: this alteration is owing to its containing a considerable proportion of mucilage, of which chemists have endeavoured to purify it. Before means were found out by which that might be accomplished, it was preserved in glass bottles, and covered with oil. Some people proposed to put sand into the vessels; others added a mineral acid; either of these processes altered the nature of the juice. The first was superior to the others; but even with it, the juice, in the space of a few days, contracted a tart, oily, and disagreeable taste. M. Georgius, in the year 1774, published, among the Acts of the Academy of Stockholm, a process for concentrating the acid juice of citrons, and rendering it unalterable. He directs this juice to be kept for some time in the cellar, in inverted bottles, in order to separate from it a part of the mucilage, and to expose it to a cold three or four degrees under o in Reamur's thermometer; the aqueous part freezes, carrying with it, as would appear, a portion of the mucilaginous matter: care must be taken, as the ice forms, to separate the liquid from it; and the congelation must be carried on till the ice become acid. M. Georgius has found, that when the juice is reduced to an eighth part of its bulk, and is eight times as strong as before, a

drachm of citron juice, concentrated by congelation, will ſaturate thirty-ſix grains of potaſh, which would require to ſaturate it an ounce of the ſame juice before concentration. This acid, thus concentrated, may be employed for many œconomical purpoſes. Dry lemonade is prepared by mixing it with ſugar refined and reduced to powder, in the proportion of one part to ſix.

Citron, or lemon-juice, if expoſed ſoon after its preparation to an atmoſphere above the temperature of 15° of Reamur, depoſites a white ſemi-tranſparent, mucilaginous matter, of a gėlatinous conſiſtency; this juice, when decanted and filtered, becomes leſs liable to alteration than before. The mucilaginous matter, when dried, does not diſſolve in boiling water: when treated with the acid of nitre, it affords gas azote, and is converted into oxalic acid: this is not a gummy mucilage, but bears an analogy to the vegetable gluten, of which we ſpoke in the article *farina*.

M. Dubuiſſon has preſerved citron-juice by a proceſs directly oppoſite to that of M. Georgius. On evaporating this juice by a moderate heat long continued, the mucilage becomes thick, and ſeparates in the form of a cruſt and glutinous flakes; the acid liquid is concentrated, and may be long kept in well ſtopped bottles, without being liable to alteration. M. Dubuiſſon has obſerved, that the contact of the air which remains between the ſtopper and the ſurface of this acid liquor concentrated by evaporation, is ſufficient to ſeparate in a few weeks flakes of a white ſubſtance, which he thinks to be glutinous, and which collecting on the ſurface, form there an elaſtic conſiſtent body. The acid is not ſenſibly altered during this ſeparation.

These

These are the several processes which were proposed and used, before Scheele's time, for purifying and preserving citron-juice. From them it appears, indeed, that this acid had engaged the attention of chemists; but it was prepared only for the purposes of pharmacy; and so fully was every one persuaded that its nature was the same with that of the acid of tartar, that no doubt was ever suggested of that being the case. Stahl had asserted, that lemon-juice, when saturated with the lobster-stone, or with chalk, acquired the nature of vinegar. Several chemists had attempted to combine it with alkalis, without obtaining permanent crystals from the combination, on account no doubt of the mucilage so plentifully mixed with it. M. de Morveau, however, informs us, that by saturating lemon-juice with carbonate of potash, exposing the solution to the air, and filtering it several times, he obtained from it a salt crystallized in small opaque grains not liable to deliquiate.

Scheele, in Crell's Journal, in the year 1784, gave a process for obtaining the acid of lemon very pure, separated from the mucilage and the extractive matter by which it is altered in the juice as pressed from the fruit, and in a concrete form. He first employed alcohol to separate the mucilage by coagulation, and did not succeed; the liquor, when inspissated, filtered, and evaporated, afforded no crystals. He tried the process which he had several years before discovered for purifying the acid of tartar, and obtained the acid of lemon, pure and concreted. The process is as follows: Saturate boiling lemon-juice with pulverized chalk. The acid forms with the lime a salt that is [illegible]ce soluble, and the mucilaginous and extractive substances

fubstances remain diffolved in the supernatant liquor; the precipitate is to be wafhed with lukewarm water, till it ceafe to deepen in colour; it diffolves nearly as well as fulphate of lime: it is then treated with as much fulphuric acid as is requifite to faturate the chalk, diluted in ten parts of water; and the mixture is now boiled for a few minutes. Afterwards it muft be cooled and filtered; the fulphate of lime remains on the filter; and the liquor affords, by evaporation, a concrete cryftallized acid. In this operation, it is better, as Scheele has remarked, to ufe an excefs of fulphuric acid, than to leave a little lime not faturated: as this would prevent the citric acid from cryftallizing; whereas, when there is an excefs of fulphuric acid, it remains in the mother-water.

The citric acid thus prepared is very pure and highly concentrated: its tafte is ftrongly acid; it reddens all blue vegetable colours that are fufceptible of fuch a change. Fire decompofes it, converting it into acidulous phlegm, gazeous carbonic acid, and carbonated hydrogenous gas: there remains in the retort a little coal: air effects no alteration on its cryftals. It diffolves eafily enough in water. The folution is decompofed by an actual putrefaction, which indeed takes place but very flowly. With earths and alkalis, it forms citrates of aluminous earth, barytes, magnefia, lime, potafh, foda, and ammoniac; the properties of which have not yet been examined, though they are known to differ from all other neutral falts. The nitric acid does not convert this, like feveral other vegetable acids, into oxalic acid: this appears indeed to be one of the moft powerful vegetable acids. It acts with the help of

water on various metallic ſubſtances, chiefly on zinc, iron, copper, &c.

Bergman has repreſented its affinities in the following order; lime, barytes, magneſia, potaſh, ſoda, ammoniac. M. de Breſſey of Dijon has an account of its affinities ſomewhat different from this. According to him, barytes holds the firſt place, lime the ſecond, and magneſia the third; the alkalis follow after theſe. It appears from the reſearches of both, that this acid prefers the three alkaline earths to the alkalis themſelves.

The uſes of the acid of lemon are various. With water and ſugar, it compoſes a very pleaſant drink, known by the name of *lemonade.* It is uſed in medicine as cooling, temperating, antiſeptic, antiſcorbutic, diuretic; it is eſpecially efficacious in correcting the acridity of the bile. It is ſometimes applied as a gentle eſcharotic to ſcorbutic ulcers, eruptions of the itch, and ſpots on the ſkin. When concentrated by the proceſs of M. Georgius, or that of M. Dubuiſſon, it may be put up for long voyages by ſea; and it is found of great utility on ſuch occaſions.

§ II. *Of the Gallic Acid.*

WE give the name of *gallic acid* to that which is extracted from the nut-gall, which grows on oaks in conſequence of the puncture of an inſect. This acid is generally found, either in a greater or a ſmaller quantity, in all ſour or aſtringent vegetable ſubſtances: Such are oak, aſh, willow, and the barks of theſe trees, quinquina,

simarouba, pomegranate, sumac, tormentillo, the cypress-nut, the stalk and leaves of the marsh iris, of the strawberry shrub, of the water-lily, &c.

Chemists formerly distinguished this matter by the name of the *astringent principle*: and all that they knew of it was, that it possessed exclusively the property by which its character was very distinctly marked, of producing black precipitates in solutions of iron in acids, and thus making ink. Messrs Macquer, Monnet, Lewis, Cartheuser, and Goanetti, sought to determine by experiments, in what manner this principle acts upon the metal. M. Monnet remarked, that nut-gall and astringent vegetable juices acted immediately on iron, and gave it a black colour. M. Gioanneti observed, that the atramentarious precipitate, or feculum, was not subject to the attraction of the magnet, and that iron therefore did not exist in the precipitate in a metallic state, as had been before thought. These observations might lead to the conclusion, that the astringent principle of nut-gall must be an acid, or at least performed the part of an acid in chemical operations. The Academicians of Dijon were, however, the first after these writers who distinguished, in their experiments, the astringent principle to be an acid. These philosophers have shown, 1. That the products of distilled nut-gall become black with the solution of sulphate of iron. 2. That an ounce of this substance communicates to cold water a tincture, from which 3½ drachms of extract are obtained by evaporation. 3. That this infusion reddens turnsol and blue paper. 4. That the same principle is soluble in oils, alcohol, and æther. 5. That acids dissolve without altering it, and without depriving it of the property of

producing a black precipitate of iron. 6. That its solution in water precipitates alkaline ſulphures. 7. That it entirely decompoſes all ſolutions of metals, and communicates a colour to the oxides by combining with them. 8 Laſtly, That it directly diſſolves iron, and precipitates ſilver and gold, after ſeparating them from their ſolvents.

Such are the important facts concerning this ſubſtance, which have been communicated to the world by the Academicians of Dijon. Several of them had indeed been before obſerved by different chemiſts, but none had before aſcertained the acidity of the principle

Since they communicated theſe obſervations to the world, Scheele has not only obſerved, that all four, aſtringent plants exhibit marks of acidity, but has diſcovered and deſcribed a proceſs for obtaining this vegetable acid pure and cryſtallized.

Upon a pound of nut-gall in powder, pour ſix pounds of diſtilled water; leave this mixture to macerate for the ſpace of fifteen days, in the temperature of from 16 to 20 degrees; then filtrate the liquor, and put it in a ſtone pot, or a large capſule of glaſs; ſuffer it to evaporate ſlowly in the air; a mouldineſs, and a thick and ſeemingly glutinous pellicle is then formed upon it: mucilaginous flakes are firſt precipitated in great abundance; the ſolution has no longer a very aſtringent taſte but is more ſenſibly acid than before. After it has been two or three months expoſed to the air, there is obſerved on the ſides of the veſſels, and adhering to them, a brown plate, covered with granulated cryſtals, ſparkling, and of a yellowiſh grey colour: the ſame cryſtals

cryſtals exiſt likewiſe in great abundance on the under ſide of the thick pellicle which covers the liquor: the liquor muſt now be decanted off; and hot alcohol is poured on the flaky ſediment, the pellicle, and the cryſtalline cruſt: this ſolvent takes up all the cryſtallized ſalt, but affects not the mucilage. This ſpirituous ſolution is then evaporated, and the gallic acid is obtained from it pure, in ſmall granulated cryſtals, of a grey colour, inclining a little to yellow, and brilliant.

The gallic acid thus purified has a taſte ſomewhat ſour and aſtringent. It produces in ſolutions of ſulphate, and of other ſalts, of iron, a very fine and brilliant black precipitate: it gives a high red colour to the tincture of turnſol; when heated in contact with air, it ſwells and kindles, diffuſing an agreeable enough ſmell, and leaves a coal, the incineration of which is very difficult: when diſtilled by a moderate fire, a part of it is diſſolved in the water of its cryſtals, and aſcends in that ſtate; another part is ſublimed, without being decompoſed in ſmall ſilky cryſtals; a ſtrong fire ſeparates from it ſome drops of oil, carbonic acid gas, and carbonated hydrogenous gas. Nut-gall, when diſtilled entire, affords a ſmall portion of concrete ſalt, reſembling the ſublimated gallic acid.

The gallic acid requires 24 parts of cold water to diſſolve it; of boiling water only three parts. Repeated ſolution and cryſtallization do not whiten it in a ſenſible manner. Alcohol diſſolves it much more efficaciouſly: four parts of this liquid, when cold, are ſufficient to diſſolve one of gallic acid; when boiling, it diſſolves a quantity of the acid equal to itſelf in weight.

This acid disengages the carbonic acid from earthy and alkaline bases, when its action is assisted by heat.

With barytes, magnesia, and lime, it forms salts soluble in water, and especially when there is an excess of the base. Potash, soda, and ammoniac, combine very readily with it, forming *gallates*, the properties of which are hitherto unknown. The nitric converts the gallic into oxalic acid.

The gallic acid precipitates gold in a brown powder, and causes a part of the metal to appear on the surface of its solution in a brilliant metallic pellicle. In the solution of silver it produces a brown precipitate; and soon after the precipitation, a plate of reduced silver appears on the surface of the liquor. From mercury it produces an orange yellow precipitate; from copper a brown precipitate; from iron a beautiful glistering black precipitate; from bismuth a citron yellow precipitate. Solutions of platina, zinc, tin, cobalt, and manganese, suffer no alteration from this acid.

Such are the properties which Scheele allows to the gallic acid prepared by his process. They are sufficient to entitle it to the character of a peculiar acid, distinct from all others. Its intimate nature, and the proportion of its principles, have not yet been ascertained. M. de Morveau obtained from it a resin which he thinks to be the acidifiable base; by the union of which with oxigene the acid is formed.

The use of nut-gall for dyeing black is well enough known: we shall only add to what we have already said of it in the article of iron, that when the pure gal-

lic

lic acid is ufed in the preparation of ink, the ink is very beautiful, and very black, and remains long unaltered.

§ III. *Of the Malic Acid, or the Acid of Apples.*

WE give the name of *malic acid* to a peculiar vegetable acid which Scheele extracted from the juice of various fruits, and of which he found apples to contain a confiderable quantity.

This acid is obtained by fqueezing the juice from four apples, faturating it with potafh, and mixing the liquor with a folution of acetite, or fugar of lead. A double decompofition is thus effected; the acetous acid combines with the potafh, and the malic with the oxide of lead; the malate of lead is precipitated; that precipitate is wafhed; and, on its being treated with fulphuric acid, fulphate of lead is produced, and the malic acid fwims above. A fufficient quantity of fulphuric acid muft be poured in to diffolve all the malate of lead; which, when it takes place, will be known from the tafte of the fupernatant liquor.

The following are the properties of this acid. It cannot be obtained in a concrete form; with the three alkalis, it forms deliquefcent neutral falts; with lime, it produces a falt that affords fmall irregular cryftals, foluble in boiling water, in vinegar, and in the malic acid itfelf; with aluminous earth, a falt that is fcarce foluble; with magnefia, a deliquiefcent falt. It diffolves iron, and the folution is brown, and not fufceptible of cryftallization; it diffolves zinc readily, and produces with it

a ſalt in very beautiful cryſtals: the nitric acid changes it into oxalic acid; it precipitates nitrate of mercury, lead, ſilver, and gold, in a metallic ſtate: calcareous malate decompoſes ammoniacal citrate, forming, in conſequence of the decompoſition calcareous citrate, not ſoluble in boiling water or in vegetable acids. The ſolution of calcareous malate in water is precipitated by alcohol; laſtly, The malic acid is ſpeedily deſtroyed by fire, which changes it into carbonic acid: the carbonic acid, thus formed, ſaturates in part the baſes of the malates decompoſed by heat. Such are the properties which form the peculiar character of this acid.

Scheele found it almoſt pure, or mixed with a little citric acid, in the juice of apples, of the barberry, of alder twigs, of the ſloe-thorn, of the ſorb-tree, and of the plum-tree; in gooſeberries, cherries, ſtrawberries, raſpberries, &c. Laſtly, He obtained it from ſugar by the nitric acid; and M. de Morveau remarks, that the malic acid ſhows itſelf in this caſe before the oxalic.

When ſour fruits contain both citric and malic acid, the following is Scheele's proceſs for ſeparating them, in order to obtain the latter pure. The juice of gooſeberries ſaturated with chalk, affords calcerous citrate, which, being inſoluble, is precipitated; the ſupernatant liquor holds in ſolution the calcareous malate, which is ſeparated by alcohol; but as it is ſtill in union with a mucilage, Scheele has had recourſe to another means for obtaining it pure. He evaporated the juice of gooſeberries to the conſiſtency of ſyrup; upon this ſyrup he poured alcohol, which diſſolved the acids without affecting the mucilage; he then filtrated the ſolution to ſeparate the mucilage; after the filtration of the liquor, he

evaporated

he evaporated the alcohol; the acids he saturated with chalk. The citric acid uniting with the chalk, was of consequence deposited in calcareous citrate; and the calcareous malate remained in solution. A new addition of alcohol precipitated it from the liquor; and Scheele then obtained the malic acid by dissolving this salt in water, precipitating the solution by acetite of lead, and decomposing the malate of lead by the sulphuric acid; the malic acid was then found separate in the supernatant liquor.

§ IV. *Of the Benzoic Acid, or the Acid of Benzoin.*

SINCE the days of Blaise de Vigenere, who wrote in the beginning of the last century, benzoin has been known to afford, by distillation, an acid salt crystallized in strong smelling needles, of an acrid taste, which in pharmacy are called *flowers of benzoin*. Chemists formerly thought this to be a particular modification of a mineral acid; but its distinctive properties are now so well known, that we can no longer doubt of its being a peculiar vegetable acid.

This acid is found to exist in benzoin, balm of Peru and Tolu, storax, liquidambar, and vanilla, around which it is crystallized. Scheele has found it likewise in the sugar of milk and the extract of urine. It will be shown under the article of *benzoin*, that the simple process which was formely employed to obtain it, consisted in sublimation by a moderate fire. Geoffroy discovered, in the year 1738, that it might be extracted by water, and that the saline substance was fully formed as it existed in benzoin; by the same process, I extracted it from

Peruvian balm, ſtorax, and the huſks of vanilla. But this proceſs affords only a ſmall quantity; for the reſin of benzoin, not mixing with the water, covers and preſerves a great part of the acid ſalt.

Scheele, in the year 1776, gave, in the Memoirs of Stockholm, ſome important obſervations on the benzoic acid: from ninety-ſix parts of benzoin he obtained, by ſublimation, between nine and ten parts of this ſublimated ſalt which was very far from what Spielman aſſerted that he obtained,—namely, a fourth part of the benzoin ſubmitted to diſtillation: it appears that the chemiſt of Straſburg had taken acid of benzoin mixed with empyreumatic oil for pure acid. Scheele, having reduced benzoin to powder and mixed it with chalk, boiled upon it a quantity of water, and then filtered the liquor, which afforded no ſalt by cooling: ſulphuric acid, poured into this liquor, ſeparated the benzoic acid in powder, and ſhowed that acid to have been united with a baſe of chalk, with which it formed a neutral ſalt ſoluble in water: the quantity of concrete acid, however, precipitated by this proceſs, was not more conſiderable than that which is obtained by ſimple lixiviation. Scheele thought that a greater quantity might be obtained by employing a matter capable of acting on the reſin, and facilitating the ſeparation of the ſalt. Potaſh did not ſerve his purpoſe; the reſin again collected on the ſurface of the liquor in a thick tenacious oil, on which account he could not expect the acid to be entirely ſeparated. With quicklime he was more ſucceſsful. According to him it is to be applied in the following manner: Take four ounces of quicklime; ſlake it with twelve ounces of water; add eight pounds more when the ebullition ceaſes;

mix

mix six ounces of this water with a pound of benzoin in powder; these substances need to be well stirred, in order that they may mix properly; pour in by degrees the remaining part of the lime-water; when the lime-water is thus gradually poured in, it hinders the benzoin from collecting into a mass: this liquor must next be heated for half an hour by a moderate fire, and constantly stirred: it is then taken off the fire, and suffered to settle for several hours together: the clarified liquor is now decanted off; eight pounds of water are poured upon the residue; it is boiled for half an hour, and then mixed with the clarified liquor before poured off from it; the operation is finished by putting the residue upon a filter, and pouring hot water upon it. These lixivia are next reduced all to two pounds by evaporation; a little resin is separated: when the evaporated liquor is cooled, a quantity of muriatic acid is dropped upon it, till it cease to produce a precipitate, and the liquor take a discernible acid taste: the salt of benzoin is then precipitated in powder. It is to be edulcorated on the filter; when it is wanted in crystals, it is dissolved in five or six times its weight of boiling water; it is then filtrated through a cloth, and the solution slowly cooled; the salt is deposited in oblong compressed prisms. In this process the lime absorbs the benzoic acid, and forms with it calcareous benzoate, which is very soluble; and the resin is separated from that salt, which has but very little affinity with it. The muriatic acid which attracts lime with more force than the benzoic acid, seizes that earth, and separates the vegetable acid. The liquor, when reduced to two pounds by evaporation, is no longer sufficient to maintain the acid in solution, and

it is therefore almoſt all depoſited. Calcareous benzoate has not the ſmell of benzoin; but as ſoon as the benzoin is ſeparated by the muriatic acid, it takes that lively ſmell which is peculiar to this balſamic ſubſtance. By this proceſs Scheele obtained twelve or fourteen drachms of benzioc acid from the pound of benzion; whereas ſublimation affords only nine or ten. He farther informs us, that the purification of this ſalt by hot water and by cryſtallization, cauſes a great quantity of it to be loſt, and is by no means neceſſary to prepare it for pharmaceutical purpoſes. In fact, this ſalt, when properly cryſtallized, is very difficult to be reduced to powder; and the deſign of the purification is to ſeparate only about two grains of reſin from the pound of benzoin. Laſtly, He remarks, that the filtration of this acid, diſſolved in water, can be effected only through a linen cloth. The ſalt being ſeparated quickly, as the liquor cools, ſtops up the pores of paper, ſo that the filtration cannot take place.

Since theſe experiments of Scheele's were made known to the world, M. Lichtenſtein has publiſhed in Germany ſome obſervations on the benzoic acid; in which he aſſerts, that ſublimation affords more of this acid than the proceſs by lime-water; but I agree with Scheele and Morveau, in thinking that this can be ſaid only of the purified acid.

The purified benzoic acid has a taſte ſomewhat ſour, pungent, hot, and acrid; its ſmell is only a little aromatic; it communicates an high red colour to the tincture of turnſol.

Heat, while it volatilizes this acid, increaſes its ſmell amazingly. When expoſed in a ſilver ladle to the heat

produced

produced by the blow-pipe, it becomes liquid, as has been obſerved by M. Lichtenſtein, and evaporates without inflammation. When ſuffered to cool, it forms a ſolid cruſt, which exhibits on its ſurface ſome marks of cryſtallization in divergent radii. It does not burn with flame, unleſs when in contact with bodies that are burning with a ſtrong flame. Burning coal only ſublimates it rapidly.

Air appears to have no power of acting on this acid; for after being preſerved twenty years in a glaſs-veſſel, a quantity of it was ſtill very pure, and had loſt nothing of its weight: it loſes its ſmell indeed; but that it regains by heat.

The benzoic acid is ſcarce ſoluble in cold water. It appears from the experiments of Meſſrs Wenzel and Lichtenſtein, that 400 grains of cold water diſſolve no more than one grain of this acid; but the ſame quantity of boiling water diſſolves twenty grains of it; nineteen of which are ſeparated by cooling. Bergman ſays, that boiling water diſſolves one twenty-fourth of its own weight, and that water of a moderate temperature diſſolves ſcarcely one five-hundredth part.

The benzoic acid combines with all earthy and alkaline baſes, forming with them benzoates of aluminous earth, barytes, magneſia, lime, potaſh, ſoda, and ammoniac. We know not the particular characteriſtic properties of each of theſe combinations, nor the different affinities of the acid with each of theſe baſes. M. Lichtenſtein aſſerts, that it prefers the fixed alkalis, and even ammoniac, to aluminous, magneſian, or calcareous earth; but a great many more experiments are neceſſary to determine exactly the order of theſe aff

ties: And these are the more necessary, because Bergman has given a different account of them. According to him, lime separates the alkaline bases, and barytes separates lime: it disengages carbonic acid from all of these bases.

The concentrated sulphuric acid dissolves it easily without either noise or heat, according to the same chemist; but passes, in consequence of effecting this solution, into the state of sulphureous acid; the benzoic acid may be separated from it unaltered by water.

The nitric acid likewises dissolves it, and gives it up in the same manner to water without alteration. M. de Morveau has caused these two bodies to re-act on each other with additional force by the application of heat. The nitrous gas was not disengaged till the end of the operation; and the benzoic acid was separated without loss, and without alteration. M. Hermstadt, however, says, that when the concentrated nitrous acid is employed, the benzoic acid becomes fluid, and more fixed in its nature, and assumes the characteristics of the tartareous or oxalic acid: but new researches are necessary to establish the truth of this result, to which little confidence can at present be given. That which appears to be most certain concerning this acid is, that it differs in its nature and properties from all other vegetable acids, and retains in it an essential oil, to which it owes its smell, volatility, combustibility, and solubility, in alcohol.

CHAP.

CHAP VI.

Of Vegetable Acids, partly saturated with Potash, and of the same Acids pure.

IN the fourth chapter, we mentioned a particular class of vegetable acids; which, we said, were in part combined with potash. We know of two acids of this character, the acid of tartar, and the acid of sorrel. We call these acids which are partly neutralized, *acidulæ;* the one is the tartareous, the other the oxalic.

§ I. *Of the Tartareous Acidula, or Tartar, and of the pure Tartareous Acid.*

THE tartar sold in the shops is an essential acid salt, combined with a portion of potash and of oil, which is deposited on the sides of hogsheads containing wine, during the insensible fermentation of the wine. It is not, as some chemists have thought, a product of vin[illegible] fer.

mentation; for Rouelle the younger has found it fully formed in muſt and in verjuice. Many other chemiſts have ſince found it fully formed in various fruits.

It is in the form of irregular plates arranged in ſtrata, often full of brilliant cryſtals, and of an acid vinous taſte. It is diſtinguiſhed into white and red tartar; the latter of which differs from the former only in containing a greater quantity of colouring extractive matter.

Crude tartar, when expoſed to fire in cloſe veſſels, affords a reddiſh acid phlegm, an oil that is at firſt light, but afterwards ponderous, coloured, and empyreumatic, a little ammoniac, and a great quantity of carbonic acid, which Hales, Boerhaave, and many other chemiſts have taken for air. There remains a coal which contains a good deal of carbonate of potaſh, and is eaſily incinerated. By the combuſtion and incineration of tartar, fixed alkali is obtained in a ſtate of conſiderable purity. For this end, the tartar reduced to powder is put into rolls of paper ſteeped in water; they are then put into a furnace between two layers of coal; the coal is kindled, and the tartar is then burnt and calcined: when the fire is extinguiſhed, the rolls are taken out, and are found to retain their form; the matter which they contain is lixiviated with cold diſtilled water: This lixivium is filtered, and evaporated to a pellicle; it is ſuffered to cool, in order to ſeparate from it the ſulphate of potaſh, which is formed by reſt; the water is decanted from above this ſalt, and it is evaporated and cryſtallized anew, till it ceaſe to yield ſulphate of potaſh; it is then evaporated to dryneſs, and by this means affords

potash, partly caustic, and partly combined with carbonic acid.

It is very difficult to dissolve tartar in water; for an ounce of water, 10 degrees above the freezing point, dissolves only four grains of tartar. As it contains a good deal of oily colouring matter, it is purified by solution and crystallization at Aniaen and Calvisson, in the neighbourhood of Montpelier. Doctor Fizes favoured the public with an account of this purification, in a Memoir printed among the Memoirs of the Academy for the year 1725.

The tartar is boiled in water; the boiling solution is filtrated; as it cools it becomes turbid, and deposites irregular crystals, which form a paste. This paste is boiled in copper vessels with water, in which there is a mixture of clayey earth, which comes from the village of Merviel, two leagues distant from Montpelier. A froth gathers on the surface of the liquor, which is carefully skimmed off, and is succeeded by a saline pellicle. The fire is then abated; and the pellicle being broken, mixes with the crystals which are precipitated from the solution: these crystals are washed with water, to purify them entirely from a mixture of earth, with which they are contaminated, and sold under the name of *cream* or *crystals of tartar;* the only difference between the cream and the crystals being, that the cream is crystallized on the surface, whereas the crystals are deposited at the bottom of the liquor. The white clay appears to serve the purpose of separating from the tartar the superfluous oily and extractive matter which it contains.

At Venice, tartar is purified in a way ſomewhat different from this, according to M. Deſmaret's account. The ſalt is reduced to powder, and diſſolved in boiling water; it is ſuffered to depoſite any impure matters which it contains; and theſe are carefully taken out: the liquor then affords cryſtals by reſt and cooling. Theſe cryſtals are again diſſolved in water, which is expoſed to a gentle heat: when this new ſolution is heated to ebullition, beaten whites of eggs and aſhes, previouſly paſſed through a ſieve, are put into it. This mixture of aſhes is repeated 14 or 15 times; the ſcum produced by the effervеſcence of the liquor is taken off; and it is then ſuffered to ſettle. A pretty white pellicle, and ſaline cryſtals of the ſame colour, are ſoon formed: the water is then decanted off, and the ſalt dried. By this method the nature of the tartareous acidulum is in ſome degree altered, and a part of it is changed into tartarite of potaſh. The cream of tartar, or purified tartar of Montpelier, muſt be the ſubject of our examination, in order that we may underſtand the nature of the pure tartareous *acidulum*.

The tartareous acidulum, when very pure, is cryſtallized, but in an irregular manner. Its taſte is ſour, and not ſo vinous as that of crude tartar. When it is put on a burning coal, it diffuſes a good deal of ſmoke of a pungent empyreumatic ſmell; and becomes black and carbonaceous. When this ſubſtance is ſubmitted to diſtillation in an earthen retort, with a balloon terminating in a tube, entering a bell-glaſs full of water, it affords, if the fire be gradually applied to it, a phlegm which is at firſt a little coloured, and ſomewhat acid:

there

there passes after this an acid which is stronger and of a deeper colour; an oil which by degrees acquires colour and consistency, and has an empyreumatic smell; ammoniacal carbonate; and a large quantity of carbonic acid. In the retort, there remains a good deal of coal, which, when lixiviated without incineration, affords a large proportion of potash. All of these products may be rectified by a new distillation at a moderate fire. The phlegm passes almost colourless; the oil, by this rectification, becomes very white and volatile; the ammoniac is in part combined with the acid, and can only be obtained separate and pure by distilling the last portions of the phlegm with an addition of potash. With respect to the coal, the potash which it contains is not produced in the course of the operation, as has been thought by some chemists not well acquainted with the nature of *cream of tartar*; but exists in it ready formed before the operation. The production of the ammoniac is owing to the re-action of this alkali on the oil. A still greater quantity of the volatile salt may be obtained by distilling the oil obtained from the tartareous acidulum upon the coal which it leaves, when analysed in the retort. The proximate cause of the formation of the ammoniac is the combination of the azote of the potash with the hydrogene disengaged from the oil.

The tartareous acidulum suffers no alteration from air. It dissolves in twenty-eight parts of boiling water, and crystallizes by cooling, but in a very confused manner. There is a certain quantity of earth separated from the solution of this salt, which, no doubt, is a part of the earth that was employed to purify it. This so-

lution reddens the tincture of turnsol, and has an acid taste. When left exposed to the air, it becomes turbid, and, after some time, deposites mucilaginous flakes: the acid is then decomposed, and the liquor is, after this, found to contain nothing but carbonate of potash. M. de Machy was the first who observed this decomposition. Messrs Spielman and Corvinus likewise attended to it; but M. Berthollet has observed it with still greater accuracy than any former philosopher. He has observed, that two ounces of tartareous acidulum require eighteen months before they can be entirely decomposed; that these two ounces will afford, in that time, six and a half drachms of carbonate of potash, still oily, and mixed with a small quantity of carbonaceous matter; and that, therefore, the quantity of alkali obtained by this means from the tartareous acidulum is precisely the same which it would afford by combustion and calcination. The alkaline residue which remains after the distillation of this acidulum, and this spontaneous decomposition, prove, therefore, that it contains a proportion of potash, nearly equal to one-fourth of its weight.

We know nothing of the action of siliceous, and very little of the action of aluminous earth, and barytes on the tartareous acidulum. The chemists of the Academy of Dijon have observed, that magnesia forms with this acidulum a soluble salt, liable to be decomposed by fixed alkali; the solution of which affords, by evaporation in the open air, small prismatic radiated crystals. When exposed to fire, this tartarited magnesia emits bubbles, and is converted into a light coal. M. Poulletier de la Salle obtained from this combination, a gelatinous mass,

perfectly

perfectly like a mucilage. These phænomena depend on the particular state of the tartareous acidulum; which is in part saturated in this acidulated vegetable acid.

A number of chemists have given very good descriptions of the manner in which lime and chalk affect the tartareous acidulum. When chalk is cast into a solution of this acidulum, an effervescence takes place, owing to the disengagement of the carbonic acid, and a very copious precipitate is formed; the precipitate is a combination of lime with the tartareous acidulum. The supernatant liquor contains a neutral salt ready formed in the acidulum; or *cream of tartar*, which consists of the pure acid in union with potash: This salt, as we will hereafter see, has been improperly called *soluble tartar*. We are indebted to Rouelle the younger for this analysis of the tartareous acidulum by chalk. It proves, 1. That this substance consists of an excess of oily acid, and a certain quantity of the same acid, united with potash in the state of a neutral salt. 2. That the combination of the tartareous acid with lime, forms a neutral salt, which is scarcely soluble. M. Proust has discovered, that calcareous tartarite, distilled in a retort, leaves a residue that takes fire in the air like the pyrophorus.

The tartareous acidulum very readily combines with the different alkalis. Put into a solution of carbonate of potash a quantity of tartareous acidulum in powder; a lively effervescence is produced by the disengagement of the carbonic acid: let acidulum be added till the alkali be saturated; after boiling this liquor for half an hour, filtrate it, evaporate the filtrated liquor to a pel-

licle, and ſuffer it to cool ſlowly; oblong ſquare cryſtals, terminating ſlopewiſe at two of their extremities, will be formed. This ſalt has been called *vegetable ſalt, ſoluble tartar, tartarized tartar;* but it ought to be called *tartarite of potaſh.* Its taſte is bitter; when expoſed to a ſtrong heat, it becomes carbonaceous: it may be decompoſed in a retort; and it then affords an acid phlegm, oil, a good deal of carbonic acid, and a little ammoniacal carbonate. It attracts, in ſome degree, the moiſture of the atmoſphere. It diſſolves in four parts of water heated to the temperature of 40°. This ſolution is decompoſed of itſelf in a few months; and it then leaves tartareous acidulum in combination with carbonic acid. The mineral acids decompoſe it, and precipitate the tartareous acidulum. It is alſo decompoſed by moſt metallic ſolutions.

The tartareous acidulum, combined with ſoda, forms the *ſalt of Seignette,* who was an apothecary of Rochelle, and the firſt that made up this combination; we give it the name of *tartarite of ſoda.* To prepare it, put 20 ounces of the acidulum of tartar into four pounds of boiling water; add by degrees very pure cryſtallized carbonate of ſoda, till the acidulum be ſaturated; that is, till the addition of the alkaline ſalt no longer produce any effervеſcence. This combination renders the tartareous acidulum ſoluble. Evaporate the liquor almoſt to the conſiſtency of ſyrup; and you then obtain from it, by cooling, very beautiful and regular cryſtals, often of a conſiderable ſize. Theſe are priſms with ſix, eight, or ten, unequal ſides, with their extremities truncated at right angles. Theſe priſms are generally divided longitudinally into two; and the baſe on which

they ſtand is marked with two diagonal lines, which croſs each other ſo as to divide it into four triangles. Tartarite of ſoda, which was at firſt ſold as a ſecret, and which was diſcovered at the ſame time by both Boulduc and Geoffroy in the year 1731, has a bitter taſte. It is decompoſable by fire, like tartarite of potaſh; it effloreſces in the air, on account of its containing a good deal of water in its cryſtals: it is almoſt as ſoluble as tartarite of potaſh; and is, like it, decompoſable by air, by mineral acids, and by metallic ſolutions. The mother-water of this ſalt contains that portion of tartarite of potaſh which entered into the compoſition of the tartareous acidulum.

Ammoniac forms with the acidulum of tartar an ammoniacal tartarite, which cryſtallizes very well by evaporation and cooling. Bucquet ſays, that its cryſtals are rhomboidal pyramids. Macquer ſaw ſome of them in large priſms, of four, five, or ſix ſides; others ſwelled in the middle, and terminating in very acute points; and the Academicians of Dijon obtained this ſalt in parallelopipeds, with two alternate ſloping ſides. This ſalt, ammoniacal tartarite, has a freſh taſte, and is decompoſable by fire: it effloreſces in the air; it is more ſoluble in hot than in cold water; and it cryſtallizes by cooling: lime and the fixed alkalis diſengage the ammoniac; the contact of air, mineral acids, and metallic ſolutions, decompoſe it. It appears, that when this ſalt is prepared, the tartarite of potaſh, which, in union with the tartareous acid, conſtituted the acidulum, or *cream of tartar*, remains in the mother-water.

Pott and Margraff have treated the tartareous acidulum with mineral acids; and the latter obtained neutral

falts, the fame with thofe which the fame acids form with potafh: from which he has inferred, that potafh exifts ready formed in the acidulum. Rouelle the younger, who profecuted a fimilar train of experiments, obtained the fame refults. On throwing a pound of concentrated fulphuric acid on an equal weight of tartareous acidulum in a very fine powder, the mixture becomes hot; the reciprocal action of the two fubftances may be promoted by the heat of a *balneum mariæ*, and by ftirring them with a fpatula of glafs: let the heat be continued for ten or twelve hours; the mixture will then become thick like a jelly: then pour upon it two or three ounces of boiling diftilled water, to render it fluid; and leave it on the *balneum-mariæ* for about two hours; then take off the fire, and add three pints of boiling diftilled water: the folution is now coloured and opaque; it contains naked fulphuric acid, a portion of tartareous acidulum, not decompofed, and fulphate of potafh. Saturate the excefs of fulphuric acid with chalk; a precipitate of fulphate of lime, with a fmall portion of tartareous acidulum, is then produced: filtrate the mixture, and evaporate the filtrated liquor; it now affords fo much tartareous acidulum and fulphate of lime, that it is reduced to eighteen or twenty ounces. It is next decanted and evaporated anew; and it affords, by reft, cryftals of fulphate of potafh; which may be thus obtained by repeated evaporation and cryftallization, till the whole folution be exhaufted. This falt is always mixed with a little of the tartareous acidulum, and it burns upon red iron; but when lixiviated with a fufficient quantity of diftilled water, it is diffolved, and the acidulum remains on the bottom of the veffel.

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This proceſs has been deſcribed, and ſucceſsfully repeated, by M. Bemiard, after Rouelle.

The nitric and the muriatic acids, when treated in the ſame manner with the tartareous acidulum, afford nitrate and muriate of potaſh; which proves incontrovertibly the exiſtence of potaſh in that ſubſtance.

The tartareous acidulum acquires ſolubility by union with borax and the boracic acid. According to the experiments of M. de Laſſone, one part of the latter ſalt will render four parts of the tartareous acidulum ſoluble. This mixed ſolution affords, by evaporation, a greeniſh gummy ſalt, which is very acid. Common borax, when added to the tartareous acidulum, converts a part of the acid into tartarite of ſoda, in conſequence of the ſoda which it contains.

The tartareous acidulum appears to be capable of uniting, without decompoſition, with moſt metallic ſubſtances; as has been ſhown by M. Monnet, and the chemiſts of the Academy of Dijon. But as all of theſe combinations have been but very little examined, we ſhall here ſpeak only of thoſe in which the acidulum is combined with antimony, mercury, lead, and iron; becauſe theſe compounds are better known, and are moſtly employed in medicine.

The combination of the tartareous acidulum with antimony bears the name of *ſtibiated*, or *antimoniated tartar*. It conſiſts of tartarite of antimony and potaſh. As it is one of the moſt valuable medicines which chemiſtry can ſupply, we muſt examine its properties with care. Since the time of Adrian, who firſt made it known to the world in the year 1631, the method of preparing it

it has been much varied. All the pharmacopœiæ, as well as the works of chemists, differ, either in respect to the antimonial substances to be employed in this preparation, or in respect to the proportions in which these, the water, and the tartareous acidulum, are to be mixed; or, lastly, in respect to the process by which these substances are to be united in stibiated tartar. In Bergman's Dissertation on this medicine, there is an excellent table of the various processes which have been given for the preparation of tartarite of antimony. The sublimated vitreous white oxide, the brown, and the orange-coloured oxides of antimony, have been successively recommended for this purpose. Some have directed to boil these substances with the tartareous acidulum, and a greater or a less proportion of water, for ten or twelve hours; others think half an hour's boiling sufficient: lastly, some writers prefer the evaporation of the filtrated lixivium to dryness; while others would have it to be crystallized, and only the crystals used in medicine. From these various modes of preparation, it happens, that tartarite of antimony can scarce ever be purchased twice precisely of the same strength and nature; and its effects can never be depended upon. Geoffroy, who had examined several sorts of *stibiated tartar* of different degrees of strength, found by analysis, that the weakest *stibiated tartar* contains in the ounce from thirty grains to a dram and eighteen grains of oxide of antimony: that which is moderately emetic, a dram and a half; and that which acts with most energy, no less than two drams and ten grains. The vitreous oxide of antimony

mony has been preferred to other antimonial ſubſtances for this preparation; becauſe it diſſolves eaſily by the acidulum of tartar: but this metallic glaſs may happen to be more or leſs oxidated: and according as it is more or leſs oxidated, it will be more or leſs emetic. However, a tranſparent vitreous oxide of antimony, levigated, and boiled in water with an equal quantity of tartareous acidulum, till the latter be completely ſaturated, then filtrated and evaporated by a moderate heat, affords, by reſt and cooling, cryſtals of antimoniated tartarite; the effects of which, as emetics, may be ſafely depended upon. Decant the liquor, evaporate it, and you obtain by ſucceſſive evaporation a new quantity of cryſtals. The mother-water contains ſulphur and tartarite of potaſh, with a certain quantity of antimoniated alkaline ſulphure. When the mixture of tartareous acidulum, vitreous oxide of antimony, and water, which were boiled for the preparation of antimoniated tartarite, is filtrated, there remains on the filter a ſeemingly gelatinous, yellow, or brown matter, of which Rouelle has taken notice. According to M. Prouſt, this jelly, when diſtilled, affords a very inflammable pyrophorus.

Macquer has propoſed the uſe of white oxide, precipitated from muriate of antimony by water, inſtead of the vitreous oxide of antimony. This oxide is a violent emetic; and Macquer thought it conſtant in its effects. Bergman has adopted Macquer's opinion; and in the laboratory of the Academy of Dijon, tartarite of antimony has been ſince prepared, according to the method of that chemiſt and M. de Laſſone. This preparation has been very ſucceſsfully employed: the requiſite doſe is three grains; and r

does not affect the ſtomach or the inteſtines too violently.

Tartarite of antimony cryſtallizes in trihædral pyramids. It is very tranſparent; it is decompoſed, and rendered carbonaceous by fire; in the air, it effloreſces, takes a dead white colour, and becomes farinaceous. It diſſolves in ſixty parts of cold water, and in a much ſmaller proportion of boiling water; it cryſtallizes by cooling; alkalis and lime decompoſe it. Calcareous earth and pure water in a large proportion, are capable of decompoſing it; and it ſhould therefore be adminiſtered only in diſtilled water. Alkaline ſulphures, and ſulphurated hydrogenous gas, produce in its ſolution a precipitate of a red powder, which is a kind of ſulphurated oxide of antimony; and may be employed to aſcertain the preſence of this ſalt in any liquor with which it may happen to be mixed. Iron ſeizes the tartareous acid, and ſeparates the oxide of antimony: ſtibiated tartar, therefore, ſhould not be prepared in iron veſſels. M. Durande, a phyſician and profeſſor at Dijon, has propoſed, that this medicine ſhould be publicly prepared by one uniform proceſs, in the ſame manner as theriaca. Such a method could not but be very advantageous; the phyſicians might then all depend on the effects of this medicine. It appears that tartarite of antimony contains that portion of tartarite of potaſh which entered into the compoſition of the tartareous acidulum; and is therefore a ſort of triple ſalt. The tartareous acid may be combined with mercury in two ways. The one, which is mentioned by M. Monnet, conſiſts in diſſolving in boiling water ſix parts of the tartareous acidulum with one part of oxide of mercury, precipitated

tated from the nitric acid by carbonate of potaſh. This liquor, by filtration and evaporation, afforded him cryſtals, which were decompoſed by pure water. The ſecond method of combining mercury with the tartareous acidulum, is, by pouring a nitric ſolution of this metal into a ſolution of tartarite of potaſh or ſoda: a precipitate is thus obtained, which conſiſts of mercurial tartarite; and the nitrite of potaſh or ſoda remains diſſolved in the liquor.

The tartareous acidulum acts in a ſenſible manner upon oxide of lead. Rouelle the younger obſerved, that the tartarite of lead formed in this operation does not remain diſſolved in the liquor; and that the liquor, when evaporated, affords only pure tartarite of potaſh, which exiſted, ready formed, in the tartareous acidulum. This is one of the proceſſes which he employed to aſcertain the preſence of potaſh in tartar.

Copper and its oxides are eaſily acted upon by the tartareous acidulum: the reſult is a beautiful green ſalt, ſuſceptible of cryſtallization; but it has not hitherto been carefully examined.

Iron is one of thoſe metals on which the tartareous acidulum acts with the greateſt efficacy. A medicine, called *chalybeated tartar*, is prepared by oiling four ounces of levigated iron filings, with a pound of white tartar, in twelve pounds of water. When the tartar is diſſolved, the liquor is filtrated; it depoſites cryſtals; and theſe may be repeatedly obtained by evaporating the mother-water. To prepare *tartarized tincture of Mars*; make a paſte of ſix ounces of iron fil of white tartar in powder, and a ſuffic ter: let this mixture ſtand undiſ

hours; next, dilute it in twelve pounds of water, and boil the whole for two hours, adding water to ſupply the room of that which is evaporated; decant off the liquor, filtrate it, and concentrate it to the conſiſtency of a ſyrup, adding an ounce of alcohol. Roulle obſerved, that the potaſh exiſts at liberty in this tincture; and that, by treating it with acids, neutral ſalts are obtained; which demonſtrate beyond a doubt the preſence of the alkali. There are two other medicines formed by the combination of the tartareous acid with iron; one of theſe is *ſoluble martial tartar*, which is a mixture conſiſting of a pound of *tartarised tincture of Mars*, with four ounces of tartarite of potaſh, evaporated to dryneſs. The other is known by the name of *balls of Mars*. Theſe are prepared by putting one part of filings of ſteel, with two parts of white tartar in powder, into a glaſs veſſel, with a certain quantity of brandy: when the liquor is evaporated, pulverize the maſs, and add more brandy, which evaporate again as before: repeat this proceſs till the mixture become greaſy and tenacious; then make it up into balls.

Crude tartar is of great uſe in dyeing; hat-makers likewiſe make uſe of it.

The ſeveral preparations of the tartareous acidulum, which we have here enumerated, are chiefly employed in medicine. The pure tartareous acidulum is thought to be refreſhing and antiſeptic; in doſes of half an ounce, or an ounce, it acts as a gentle purge, without exciting nauſea. Tartarite, both of potaſh and ſoda, is frequently taken in doſes of a few drams, to aſſiſt the action of other purgative medicines. Tartarite of antimony is one of the moſt uſeful and moſt powerful medicines which chemiſtry

miſtry affords. This ſalt is emetic, purgative, diuretic, diaphoretic, or diſcuſſive, according to the doſes, and the circumſtances in which it is adminiſtered. It often produces even all theſe effects at once. It may be conſidered as a powerful alterative, happily qualified to remove obſtructions in the viſcera, when adminiſtered in ſmall and repeated doſes. It is given as a vomit in doſes of from one to four grains, diſſolved in a few glaſſes of water. A grain of it is ſometimes mixed with other medicines to aſſiſt their action: laſtly, It acts as an alterative when taken, half a grain at a time, diluted in a large proportion of water. M. de Laſſone has diſcovered, that tartarite of antimony is rendered very ſoluble in water, by mixing with it ammoniacal muriate; and that there reſults from this mixture a ſalt of a nature ſimilar to that of ammoniaco-mercurial muriate. This new triple ſalt cannot but produce very powerful effects on the animal œconomy. *Chalybeated tartar*, *ſoluble martial tartar*, and the *tartarized tincture of Mars*, are employed as tonics and aperitives.

Such are the properties of the native tartareous acidulum, or of the tartareous acid, combined by nature with a certain quantity of potaſh. It was requiſite to examine it with care, as it is ſo very uſeful, and ſo very much employed. But this is not the pure tartareous acid; and it is of no leſs importance to know the characteriſtic properties of that ſubſtance. M. Retzius has publiſhed, in the Memoirs of Stockholm for the year 1770, a proceſs invented by Scheele for extracting and purifying this acid. Into a ſolution of two pounds of the tartareous acidulum, in boiling water, put waſhed chalk, till ſuch time as it ceaſe to produce efferveſcence, and

and there be no longer any of the acid in a ſtate of liberty: the quantity requiſite is ſomewhat more than a fourth part of the weight of the acidulum; take out the precipitate of calcareous tartarite which is now formed, place it on a filtre, and waſh it with cold water; there are uſually thirty-two or thirty-three ounces of it, on account of its containing water. The liquor decanted from above the precipitate, affords by evaporation a quantity of tartarite of potaſh, which has not been decompoſed, equal nearly to half the acidulum employed. Pour upon the calcareous tartarite, in powder, nine and a half ounces of concentrated ſulphuric acid, diluted in five pounds five ounces of water; leave this mixture to digeſt for twelve hours, ſtirring it from time to time. Decant the liquor from above the ſulphate of lime; evaporate it, after aſcertaining that it contains no ſulphuric acid. In order to that, pour into it a few drops of acetite of lead, or ſalt of Saturn: if the precipitate thus produced be ſoluble in vinegar, the lixivium may be inferred to contain no ſulphuric acid; but if the precipitate cannot be diſſolved in that fermented acid, the lixivium ſtill contains ſulphuric acid, which may be ſeparated by digeſting it on a certain quantity of calcareous tartarite. Lime may be uſed inſtead of chalk in the proceſs for obtaining the tartareous acid: But as that alkaline earth decompoſes the tartarite of potaſh contained in the tartareous acidulum, the lixivium, when lime is uſed, contains only alkali inſtead of tartarite of potaſh, as in the former proceſs. The uſe of quicklime in this decompoſition affords more of the acid, becauſe lime decompoſes twice its weight of tartareous acidulum.

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The pure tartareous acidulum obtained in a liquid ſtate by either of theſe proceſſes, muſt be evaporated to dryneſs; then diſſolved again, and cryſtallized, either by ſlow evaporation, according to M. Pæcken; or by cooling the evaporated liquor to the conſiſtency of a clear ſyrup, according to Bergman. It is obtained in the form of ſmall ſharp-pointed needles, or minute priſms; the form of which it is ſcarce poſſible to determine. Bergman deſcribes them as divergent leaves; M. Retzius compares them to hairs intwined together: They are at firſt very white; thoſe obtained towards the end of the operation are yellow.

The cryſtallized tartareous acid melts, fumes, becomes black, and even takes fire, when brought into contact with burning bodies. When diſtilled, it affords, like the tartareous acidulum, only an acid phlegm, a little oil, and a good deal of gazeous carbonic acid, mixed with carbonated hydrogenous gas. The coal which remains contains neither acid nor alkali; which proves, that no alkali is formed in conſequence of the decompoſition of the tartareous acid by fire: this acid, however pure, is always oily. For this reaſon, it is called the *tartareous acid*, and its ſalts *tartarites*.

It is not liable to alteration in the air: It is much more ſoluble than the tartareous acidulum: Its taſte is very pungent: It reddens the tincture of violets, as well as that of turnſol. It diſſolves aluminous earth, and forms with it an aluminous tartarite, which takes only a gummy or mucilaginous conſiſtency by evaporation.

In combination with magneſia, the pure tartareous

acid forms a salt; which also, instead of crystallizing, gives a sort of gelatinous matter.

By combination with lime, it affords an almost insoluble salt.

A little potash, poured into this solution, precipitates the tartareous acidulum, or *cream of tartar*, in crystals. This discovery, made by Scheele and Bergman, throws more light than any other facts known on the nature of this vegetable salt. No farther proofs are requisite, as M. de Morveau says, to determine the principles of which the tartareous acidulum consists: we know it to consist of tartarite of potash, with excess of acid; but, what is very singular, this acid, naturally very soluble, suddenly loses that property when about half saturated with potash; which, however, is very soluble by itself. This fine experiment also proves, that the tartareous acid is not in any manner altered by Scheele's process; for with about one fourth or one third of its own weight of potash, it forms an acidulous salt, similar in nature to the acidulum from which it was obtained. With a greater proportion of potash, it forms a neutral salt, completely saturated and soluble, which is tartarite of potash, or *vegetable salt.*

The tartareous acid, with soda, forms a crystallizable neutral salt, or tartarite of soda *(salt of Seignette)*, which is very pure. With ammoniac, it affords a crystallizable ammoniacal tartarite. M. Retzius informs us, that the tartareous acid, when combined with a quantity of ammoniac considerably less than what is required to saturate it, forms a scarce soluble ammoniacal tartareous acidulum, which crystallizes like the

common

common cream of tartar, or tartareous acidulum of potash.

Although the tartarites have not so strong an affinity with the alkalis, as the mineral acids; yet these latter salts, when they decompose tartarite of potash or soda, do not completely separate the base, but disengage the tartareous acid into the state of acidulum, of potash, or of soda. The pure tartareous acid does itself partly decompose sulphate, nitrate, and muriate of potash, and separates so much of the alkali as is requisite to bring it into the state of tartareous acidulum, or acidulated tartarite of potash. It does not produce the same effect on nitrate and muriate of potash.

M. Hermstadt asserts, that the tartareous becomes oxalic acid by means of the nitrous acid. Bergman could not effect this change: but he failed probably on account of employing too little of the nitrous acid. As the nitrous acid gives out nitrous gas, when it accomplishes the transmutation of the tartareous acid, the only difference between the tartareous and oxalic acids would appear to be, that the latter contains a greater quantity of oxigene.

The tartareous acid is incapable of acting on silver, gold, or platina; it dissolves their oxides. Its action on copper, lead, and tin, is imperceptible: it dissolves the oxides of these metals, and destroys the red colour of oxide of lead.

It dissolves iron with a very gentle effervescence.

It produces no alteration on antimony in a metallic state, but acts with sufficient force to dissolve its oxides.

It ſeparates lime from the nitric, the muriatic, the acetous, the formic, and the phoſphoric acids.

It precipitates the nitric ſolution of mercury, the muriatic ſolution of lead, &c.

Its attractions are repreſented by Bergman in the following order: lime, barytes, magneſia, potaſh, ſoda, ammoniac, aluminous earth; oxide of zinc, iron, mangneſe, cobalt, nickel, lead, tin, copper, biſmuth, antimony, arſenic, ſilver, mercury, gold, platina, water, and alcohol.

§ II. *Of the Oxalic Acidulum, or Salt of Sorrel, that is ſold in commerce, and of the pure Oxalic Acid.*

THE ſalt of ſorrel ſold in the ſhops, or the oxalic acidulum, is extracted in great quantities at Hartz, in Thuringia and Swabia, from the juice of ſorrel, called by Linnæus *oxalis acetoſella*. An hundred pounds of this plant, cut down in a ſtate of vigorous vegetation, afford, according to M. Savary, fifty pounds of expreſſed juice; which fifty pounds of juice afford only five ounces of concrete ſalt, by evaporation and cryſtallization. The ſalt of ſorrel that comes from Switzerland, is diſtinguiſhed in commerce as the moſt beautiful and the whiteſt; that from Forets in Thuringia is dirty and yellowiſh.

The juice of ſorrel has been long known to afford an acid ſalt by evaporation. Duclos mentions it in the Memoirs of the Academy for 1668: Juncker likewiſe ſpeaks of it. Boerhaave, who compares this ſalt to tartar, has given a very accurate deſcription of the

proceſs

procefs for obtaining it. M. Margraff difcovered, that potafh entered into the oxalic, as well as into the tartareous acidulum. But the nature of this falt was by no means exactly known, till the experiments of Meffrs Savary, Wenzel, Wiegleb, Scheele, and Bergman, were communicated to the world.

The oxalic acidulum exifts in fmall white cryftals, opaque, and needled or lamellated. Their form has not been yet fully afcertained; although Capeller and Ledermuller have defcribed them as they appeared through the microfcope. M. de Lifle reprefents them as very oblong parallelopipids. They confift of collections of long thin leaves, joining at one end, but feparate at the other. The tafte of this falt is four, poignant, and at the fame time bitter. It communicates a deep red colour to tincture of turnfol, and blue paper. Four hundred and eighty grains of this acidulum, diftilled in a retort by a fire, the heat of which was properly regulated, afforded M. Weigleb one hundred and fifty grains of phlegm, ftrongly acid, without either fmell or colour. There remained one hundred and fixty grains of grey falt, from which one hundred and fifty-fix grains of vegetable alkali were obtained. About four grains of concrete acid falt were likewife fublimed into the neck of the retort: not a drop of oil paffed. In this procefs of diftillation, there were one hundred and fixty-fix grains of lofs. But as M. Weigleb does not mention what elaftic fluids were difengaged in this analyfis, the lofs was probably owing to the difengagement of water in vapours, and of carbonic acid gas, mixed with a little hydrogenous gas and carbonaceous matter. By comparing this analyfis

with that of the tartareous acid, we perceive the oxalic acidulum to be lefs oily than the other The liquid acid, therefore, obtained by this diftillation, is pure oxalic acid; whereas the tartareous acidulum, when treated with fire, affords an altered acid, different in nature from the tartareous acid, which we call the *pyro-tartareous acid*. It is becaufe the acid of forrel contains fo little oil, that we call it the *oxalic acidulum* and *acid;* while to the more oily acid of tartar, the rules of our methodical nomenclature require us to give the name of the *tartareous acid.*

The oxalic acidulum, when pure, fuffers no alteration by expofure to air; it is more foluble than the tartareous acidulum. According to M. Weiglib, a drachm of oxalic acidulum from Switzerland requires to diffolve it only fix drachms of boiling water; but though other fix drachms of cold water be added, it is entirely precipitated by cooling. According to M. Wenzel, it is even much more foluble than M. Weigleb reprefents it: for he found, by experiment, nine hundred and fixty parts of boiling water to take up fix hundred and feventy-five parts of this falt: but its folubility varies, according as it is more or lefs acid; which again depends on the quality of the plant from which it is extracted.

The oxalic acidulum combines with barytes, magnefia, foda, ammoniac, with which it forms triple falt (or *trifules*). Lime decompofes it, by detaching its acid, both that part which is in a ftate of liberty, and that which is in combination with the potafh. One hundred grains of chalk decompofe one hundred and thirty-feven grains of the oxalic acidulum. The precipitate

cipitate of calcareous oxalate that is deposited, weighs one hundred and seventy-five grains; the supernatant liquor affords, by evaporation, thirty-two grains of carbonate of potash. This process cannot be used in preparing the pure oxalic acid, though the tartareous acid be obtained pure by it: for calcareous oxalate is not decomposable by sulphuric acid, like calcareous tartarite; on the contrary, the oxalic acid has so strong an affinity with lime, that it attracts this earth from all other acids; and one certain test of the purity of the oxalic acidulum, or salt of sorrel, is, to pour a solution of it into water impregnated with calcareous sulphate: when the acidulum has been really extracted from sorrel, it produces in the water a copious precipitate.

The sulphuric acid contributes to the disengagement of the oxalic acid from the acidulum by means of heat, according to M. Weiglib. The nitric acid decomposes the acidulum, and separates the alkali; but it has much more difficulty to accomplish this on the oxalic than on the tartareous acidulum, according to Margraff's experiments.

The oxalic acidulum acts upon iron, zinc, tin, antimony, and lead. It dissolves the oxides of all the other metals, forming with them triple crystallizable salts, which are not deliquescent, and in which the potash always remains in union with the acid: it precipitates the nitric solutions of mercury and silver. M. Bayen, by evaporating the supernatant liquor from above these precipitates, obtained nitrate of potash, and thus established more certainly the existence of alkali in this

To prepare the oxalic acid by ſeparating the potaſh of the acidulum, diſtillation, as we have already ſeen, may be employed : but this proceſs affords only a ſmall quantity; and that which Scheele has recommended, being eaſier performed, and more certain in its reſults, is therefore preferable. Saturate the oxalic acid with ammoniac; pour into this triple ſolution, conſiſting of oxalic acid, with ammoniac and potaſh, a quantity of barytic nitrate. A precipitate of barytic oxalate is thus produced, and the nitric acid retains the potaſh and ammoniac. After waſhing the barytic oxalate, decompoſe it with ſulphuric acid. The ſulphate of barytes, that is now formed, remains inſoluble at the bottom of the liquor. Decant off the liquor; ſeparate the portion of ſulphuric acid which may ſtill be contained in it, by barytic oxalate diſſolved in boiling water; and when it ceaſes to afford a precipitate, the liquid may be conſidered as containing pure oxalic acid, and decanted off from above the precipitate. It is next to be evaporated with proper care; and it now affords ſalt, by cooling, in quadrilateral priſms, with their ſides alternately broad and narrow, and terminating in dihædral ſummits. Theſe cryſtals are often in the form of ſquare or rhomboidal plates.

This concrete acid has a very ſtrong ſour taſte; ſeven grains communicate a ſenſible acidity to two pounds of water. It reddens all blue vegetable colours. A grain of this ſalt communicates to 3600 grains of water the property of reddening paper tinctured with turnſol.

The concrete oxalic acid, when expoſed to a moderate fire, becomes dry, and is covered over with a thick cruſt; it is in a ſhort time reduced to powder, and loſes three tenths of its weight. When diſtilled in a retort, by a ſtronger fire, which muſt not, however, be violent, it liquifies, becomes brown with ebullition, affords an acidulated phlegm, and is partly ſublimated without alteration. There is at the ſame time diſengaged from it a gas, mixed with carbonic acid, and hydrogenous gas. When expoſed to a violent heat, it affords more gas, leſs ſublimated concrete acid, and more acidulated phlegm, that is not liable to cryſtallization; at the bottom of the retort, there remains only a grey or brown maſs, amounting to one fiftieth part of the acid employed. When put upon a coal burning in the air, it emits a very acrid white ſmoke, which irritates the lungs in a very lively manner: the reſidue which it leaves is white, without any mixture of carbonaceous matter. Such is the reſult of the decompoſition of the oxalic acid by fire that was obſerved by Bergman. The Abbé Fontana has obtained near double the quantity of gas; but that, as we have already ſhown, depends on his having applied a ſtronger heat, with a view to effect a thorough decompoſition of the acid.

When expoſed to moiſt air, the concrete oxalic acid remains deliqueſcent; but in dry air it rather becomes dry. Cold water diſſolves a quantity of it equal to one half of its own weight. When cryſtals of this acid are caſt into cold water, a faint noiſe is heard, which muſt be produced by a ſudden breaking of their particles. The ſpecific gravity of this cold ſolution is 1.0593, ac-

cording to M. de Morveau. No acid vapour rises with the water of the solution when evaporated, not even by ebullition. Boiling water dissolves a quantity of this concrete acid salt equal to itself in weight: One half is precipitated in crystals by cooling.

The oxalic acid dissolves aluminous earth. This solution affords, by evaporation, a yellowish mass, transparent, soft, and astringent; which attracts moisture from the atmosphere, and reddens turnsol. This salt swells in the fire; it then loses its acid, and the aluminous earth remains a little coloured. It is decomposable by mineral acids.

In combination with barytes, it forms a scarce soluble salt; which, with an excess of the acid, affords angular crystals. Hot water, by depriving them of that excess, renders them opaque, pulverulent, and insoluble.

With magnesia, it affords a white salt in powder, which is decomposable by the fluoric acid and barytes.

The oxalic acid, saturated with lime, forms a salt insoluble in water, pulverulent, and not decomposable by fire; for so strong is the affinity between this acid and lime, that it detaches this base from every other acid. On account of this property, Bergman has proposed the use of the oxalic acid for ascertaining the presence and the proportion of lime in mineral waters, or in any combination with other acids. Calcareous oxalate gives a green tinge to syrup of violets.

The oxalic acid combines with potash; and the neutral salt, with an excess of either of the two principles, is susceptible of crystallization. Oxalate of potash is very

very ſoluble in water, and decompoſable by the action of fire and of mineral acids. Pure oxalic acid, added in drops to a ſolution of this ſalt, ſoon produces a precipitate, which appears to be oxalic acidulum, the ſame as the common *ſalt of ſorrel.*

With two thirds of ſoda, the oxalic acid forms a ſalt which is ſcarce ſoluble, but diſſolves beſt in hot water, and turns ſyrup of violets green. An exceſs of the acid forms acidulous oxalate of ſoda, which is ſcarce ſoluble.

With ammoniac, the oxalic acid affords ammoniacal oxalate, which cryſtallizes, by ſlow evaporation, into quadrilateral priſms. By fire, this ſalt is decompoſed; and then it yields ammoniacal carbonate, formed by the deſtruction of the oxalic acid. An exceſs of the acid poured into a ſolution of this ſalt, precipitates from it an ammoniacal oxalic acidulum, in cryſtals much leſs ſoluble in water than the pure neutral ſalt.

The oxalic acid is ſoluble in mineral acids. It imbrowns the concentrated ſulphuric acid; it is decompoſed by the nitrous acid, and reduced into carbonic acid in conſequence of the decompoſition. This acid generally combines much eaſier with metallic oxides than with the metals themſelves.

1. With oxide of arſenic, it forms priſmatic cryſtals, very fuſible, very volatile, and decompoſable by heat.

2. With oxide of cobalt, a pulveriſed ſalt, of a bright roſe-colour, and ſcarce ſoluble.

3. With oxide of biſmuth, a white ſalt in powder, very little ſoluble in water.

4.

4. With oxide of antimony, a ſalt in cryſtalline grains.

5. With oxide of nickel, a ſalt, of a white or greeniſh yellow colour, and ſcarce ſoluble.

6. With oxide of manganeſe, a ſalt in a white powder, which becomes black in the fire.

7. With zinc, the ſolution of which is attended with efferveſcence, a pulverulent white ſalt.

8. It diſſolves oxide of mercury, and reduces it to a white powder, which is rendered black by the contact of light. This acid decompoſes mercurial ſulphate and mercurial nitrate.

9. Tin, by its action, is firſt rendered black, and afterwards covered with a white powder. The ſalt which it forms with this metal is of an harſh taſte. It cryſtallizes into priſms, by evaporation judiciouſly conducted; when evaporated by an intenſe heat, it leaves a tranſparent maſs, reſembling horn.

10. It tarniſhes lead, but diſſolves its oxide better. The ſaturated liquor depoſites ſmall cryſtals, which may alſo be obtained by pouring oxalic acid into a ſolution of nitrate or muriate of lead, or into acetite of the ſame metal.

11. It acts on iron-filings; and as there is water decompoſed in this ſolution, there is of conſequence hydrogenous gas diſengaged. Oxalate of iron is ſtiptic: it affords greeniſh yellow priſmatic cryſtals, decompoſable by heat.

Yellowiſh oxide of iron, in combination with this acid, affords a yellow ſalt, ſimilar to that which is obtained

by

by pouring liquid oxalic acid into a ſolution of ſulphate of iron.

12. It acts on copper, and entirely diſſolves the oxides of this metal. The ſalt thus formed is of a clear blue colour, and ſcarce ſoluble. This ſalt may be likewiſe obtained by precipitating ſulphuric, nitric, muriatic, and acetous ſolutions of copper, with oxalic acid.

13. Oxide of ſilver, precipitated by potaſh, diſſolves in a ſmall proportion in this acid. The beſt way of obtaining this ſalt is by precipitating the nitric ſolution of ſilver with oxalic acid: a white ſediment is produced, ſcarce ſoluble in water, and liable to become brown by the contact of light.

14. This acid ſcarce acts on oxide of gold.

15. Laſtly, it diſſolves the precipitate of platina produced with ſoda. This ſolution is ſomewhat yellow, and affords cryſtals of the ſame colour.

Such are the phænomena of the combinations of the oxalic acid, as deſcribed by Bergman.

That celebrated chemiſt accompliſhed all theſe combinations with artificial oxalic acid, prepared from ſugar and nitric acid. Sugar, as well as all mucilages, extracts, ſweet oils, and farina, affords, when treated with nitrous acid, an acid perfectly the ſame with pure oxalic acid, as has been aſcertained by Scheele. All theſe matters, and even a great many animal ſubſtances, as has been diſcovered by M. Berthollet, contain therefore the radical principle of the oxalic acid, wanting nothing but oxigene to complete the acid.

Bergman was the firſt who diſcovered that ſugar, treated with nitrous acid, formed a peculiar acid: he gave it the name of the *acid of ſugar*, or *ſaccharine acid*; which it retained for ſeveral years, till Scheele ſhowed it to be preciſely of the ſame nature with the oxalic acid, extracted from *ſalt of ſorrel* by the proceſs above deſcribed. He ſhowed the identity of theſe acids, by forming the ſcarce ſoluble oxalic acidulum, or *ſalt of ſorrel*, from a combination of a ſmall quantity of ſoda, with the ſaccharine acid. Here, then, is a vegetable acid, which exiſts in an acid ſtate in but few vegetable matters, but of which the baſe is exceedingly copious in thoſe matters, and appears to paſs unaltered into animal bodies. In the following chapters, we ſhall ſee that this acid is probably, like all other vegetable acids, a compound of hydrogene, carbone, and oxigene; and that the only difference between it and the other vegetable acids is in the proportions of their principles.

The baſe or radical principle of the oxalic acid appears to exiſt in greater plenty in inſipid matters than in ſugar; though it was once believed, that ſaccharine bodies afforded moſt of it. From ſugar, Bergman obtained only a third part of its weight of oxalic acid: and from wool, M. Berthollet has obtained a quantity equal to more than half the weight of the wool.

The pure oxalic acid is uſed no where but in the laboratory; the chief uſe to which it is there applied, is to aſcertain the preſence of lime. The oxalic acidu-

lum,

lum, or ſalt of ſorrel, is uſed to efface ſtains of ink from white ſtuffs, wood, ivory, &c. on account of its having ſo ſtrong an affinity with iron; but the pure oxalic acid being more ſoluble, might be more advantageouſly uſed for ſuch purpoſes.

CHAP.

CHAP. VII.

Of Vegetable Acids, formed by the Action of Fire, and by the Nitric Acid.

IT has been long known to chemiſts, that many vegetable matters afford, by diſtillation, phlegms, or acid liquors: theſe ſaline ſubſtances, altered by fire, were, however, but little attended to. Since ſuch a number of acids have been diſcovered, really diſtinct from one another, either in their intimate nature, or in the proportion of their principles, many of theſe ſalts have been found to poſſeſs peculiar and diſtinctive properties. It has been alſo aſcertained, that ſome acids act, like heat, on vegetable matters, and that the nitric acid, in particular, converts moſt of them into acid. Theſe new, or newly modified ſalts, need to be carefully examined, in order that we may acquire a knowledge of their nature. We cannot avoid remarking, in the firſt place, that there muſt be a general analogy of nature, or formation, among vegetable acids, produced by the action of heat: On account of that analogy, we give them the

the generic name of empyreumatic salts; and apply to each of them, as a specific distinction, the syllable *pyro*, joined to a term indicating the origin of the salt; thus we say, the *pyro-tartareous*, the *pyro-mucous*, and the *pyro-ligneous* acids.

§ I. *Of the Pyro-Tartareous Acid.*

IT has been already mentioned, that, by the distillation of the tartareous acidulum, an acid phlegm is obtained, which is not the pure tartareous acid, but that acid altered in a particular manner. The hydrogenous gas, and the carbonic acid gas, that are at the same time disengaged, shew plainly that such an alteration must take place; for these can only be produced in consequence of the decomposition of the acid of tartar. As this alteration is owing to the action of heat, and as an oil, mixed with the distilled acid, is at the same time volatilized, which modifies its colour, we have therefore called that acid the *pyro-tartareous*, and its saline combinations *pyro-tartarites*, according to the laws of our nomenclature.

The first chemists who made experiments on this matter, with any degree of accuracy, ascertained, that, by distilling about a quarter of a pound of tartar, there might be obtained an acid phlegm of a very pungent smell, or pyro-tartareous acid. The academicians of Dijon represent the secondary rectification or distillation of this acid, which has been recommended by so many authors, as attended with one very great difficulty:—notwithstanding every precaution which they could

adopt to moderate the fire, and give room to the vapours, they always found the liquid to rise so quickly as to burst the vessels containing it, into pieces. This phænomenon they attribute to the action of gas produced by the decomposition of the acid, and compressed by the oil; which pressure it at length overcomes, as it is more dilated. Besides, the rectification is not very necessary, as the acid separated from the oil by the still-pipe is so pure as to exhibit all its distinctive characteristics.

The pyro-tartareous acid has an empyreumatic taste and smell. It does not redden syrup of violets, but it produces that effect on turnsol and blue paper: It disengages the carbonic acid from its bases with a lively effervescence. With the earths and alkalis, it forms salts very different from those which the tartareous acid forms with the same bases. These saline compounds have not yet been examined; only we know the pyro-tartarites of potash and soda, to be soluble in cold water, and crystallizable: the acid decomposes nitrate of silver, producing from it a grey precipitate; it by degrees renders nitrate of mercury turbid; it does not decompose calcareous muriate; and the sulphuric acid decomposes its neutral salts by distillation.

Chemists, before hydrogene, carbonaceous matter, and oxigene, were understood to be the sole and genuine component principles of all vegetable acids, constituting different acids only by being united in different proportions, had adopted opinions very remote from the truth, concerning the nature of this acid, obtained by distillation from tartar. Venel asserted it to be acid of nitre.

nitre. M. Monnet concluded, from a more accurate investigation of its nature, that it was muriatic acid disguised by oil and mucilage. But although Scheele found tartar to contain a little muriatic acid, yet the cubic form of the neutral salt, produced by the union of the pyro-tartareous acid with soda, and the precipitation of nitrate of mercury by this acid, the two facts on which M. Monnet establishes the identity of the pyro-tartareous with the muriatic acid, are not sufficient evidence to induce modern chemists to assent to the conclusion deduced from them. Besides, the chemists of Dijon have repeated the same experiments without obtaining the same results; nor have Messrs Berthollet, Spielman, and Corvinus, been more successful. On the contrary, it is highly probable, that the principles of the pyro-tartareous acid are the same with those of the acid of tartar itself; and that the two acids differ only in the proportion of their principles: the smell and taste of this empyreumatic acid, its not being susceptible of crystallization, and all its other properties, and still more the disengagement of oil and carbonic gas from the tartareous acidulum, when the pyro-tartareous acid is formed,—concur to prove the truth of what is here asserted.

The character of this empyreumatic acid has not yet been sufficiently investigated, to enable us to determine the order of its chemical affinities with earthy, alkaline, and metallic bases.

§ II. *Of the Pyro-Mucous Acid.*

THE acid which we denominate pyro-mucous, is that obtained from inſipid, ſaccharine, gummy, farinaceous, &c. mucilages, which was at firſt denominated by M. de Morveau the ſyrupous acid. Chemiſts have long known that ſugar affords, by diſtillation, a pretty ſtrong acid phlegm. Neuman, Cartheuſer, Geoffroy, and Bucquet, have made particular mention of that acid, but without having examined its properties. M. Schrickel has examined its nature with more minute attention than any other chemiſt.

By diſtilling 16 ounces of ſugar, M. Schrickel obtained 6 drachms of phlegm, which paſſed into the receiver in the form of white vapour, and was condenſed into unctuous ſtriæ, of a pungent ſmell, like that of horſe-raddiſh, or bitter almonds, roaſted; of an acid, acrid, and bitter taſte, and of a red yellow colour. He rectified this acid upon clay; it then paſſed clear, with a leſs pungent ſmell, and a ſour taſte. This acid, when thus purified, did not cryſtallize; but when expoſed to cold, the aqueous part froze, and that part which ſtill remained liquid, became much more concentrated.

M. de Morveau obſerved, when preparing the pyro-mucous acid by the diſtillation of ſugar, that the bottom of the retort was corroded during the operation. He does not attribute this to the acid, as it exhibits no ſuch property when rectified, or when left long in the glaſs; but rather to the action and adheſion of the carbure of iron, which exiſts in the coal that remains after the decompoſition of the ſugar, and had been violently heated. This acid, therefore, cannot be concentrated

by volatilizing the water that is united with it, as the ſalt is no leſs volatile than the fluid. This acid, according to M. de Morveau, exiſts in molaſſes, and renders them deliqueſcent, and not ſuſceptible of cryſtallization.

The pyro-mucous acid, when concentrated by freezing, is very pungent, and communicates a deep red to blue vegetable colours. It produces red ſpots on the ſkin, as was long ago obſerved by Cartheuſer; and the ſpots thus produced deſtroy the epidermis before they diſappear. When expoſed to fire, it is totally volatilized, leaving no reſidue but a brown mark on the place where it lay. Moſt of it may be converted into carbonic acid gas, and hydrogenous gas, by diſtilling it, with proper precautions, in cloſe veſſels: it now affords a more copious carbonaceous reſidue than when heated in open veſſels. A part is volatilized without alteration.

When combined with barytes, magneſia, lime, potaſh, ſoda, and ammoniac, it forms neutral ſalts, which we call *pyro-mucites*, the properties of which have not yet been examined with ſufficient care, but which differ from all other known neutral ſalts. It diſengages the carbonic acid from all of theſe alkaline baſes with a lively effervеſcence.

The property of diſſolving gold was formerly aſcribed to the ſpirit of honey; but it appears for certain, that the pyro-mucous acid does not affect either that metal, or platina, or ſilver, or even mercury; but it might poſſibly diſſolve the oxides of theſe metals. This acid corrodes lead, becoming opaque itſelf on the occaſion; which alteration it owes to the oxide of lead which it

forms. Pyro-mucite of lead is in oblong cryſtals. It acts upon copper, and becomes green by the re-action of that metal; it diſſolves tin; it acts upon iron, and combines with that metal to form cryſtals.

Its chemical affinities have been determined by M. de Morveau in the following order; Potaſh, ſoda, barytes, lime, magneſia, ammoniac, aluminous earth, metallic oxides, water, alcohol.

This empyreumatic acid has not as yet been applied to any purpoſe. Spirit of honey, of manna, &c. were formerly made uſe of in pharmacy; but the uſe of them has been long given up.

§ III. *Of the Pyro-ligneous Acid.*

WOOD, eſpecially beech, birch, and box trees, afford, by diſtillation, a brown acid liquor, of a pretty ſtrong, peculiar ſmell, which reddens blue vegetable colours, and effervеſces with alkaline carbonates. Boerhaave was acquainted with the product of box, juniper, oak, and *Guayac*: but the chemiſts who have repeated Boerhaave's proceſs, have not examined the nature and peculiar properties of this acid. M. Goettling, in the year 1779, firſt publiſhed, in Crell's Journal, a Memoir on the acid of wood, and more eſpecially on its union with alcohol. That chemiſt diſtilled the bark of birch in an iron retort: he obtained a brown, oily, acid product, which he left to ſettle for three months; at the end of that time, he obſerved drops of oil ſwimming on its ſurface, which having ſeparated by filtration, he poured into the filtrated liquor a ſolution of potaſh. A

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ſively efferveſcence took place; the liquor aſſumed a blood-red colour, and afforded, after being ſaturated with alkali, and evaporated, a black ſalt, which was melted in an iron pan, and purified by a ſecond ſolution, and a ſecond evaporation.

The pyro-ligneous acid may be alſo rectified by diſtillation, according to M. Goettling. The pyro-lignite of potaſh, formed of this rectified acid, becomes very hot when brought into contact with the ſulphuric acid, and affords pyro-ligneous acid in a ſtate of conſiderable purity. That chemiſt, to whom we are indebted for theſe facts, obſerves, that the pyro-ligneous acid, when ſeparated by the ſulphuric acid, has no longer any empyreumatic odour, but a ſmell of garlic.

The chemiſts of Dijon extracted this acid from beech, by diſtillation, and afterwards rectified the liquid product: 55 ounces of this wood, well dried, and in ſhavings, afforded 17 ounces of rectified acid, of an amber-colour, not mixed with oil, and of which the gravity was to that of diſtilled water, in the proportion of 49 to 48: $23\frac{4}{7}$ ounces of lime-water were required to ſaturate an ounce of this acid. When expoſed to a gentle heat, it aſcends in vapour. A ſtrong heat decompoſes this, as well as all other vegetable acids. It cannot be obtained in a concrete form.

It combines with earthy and alkaline baſes, and forms with them peculiar ſalts, which we call pyro-lignites of alumines, barytes, magneſia, lime, potaſh, ſoda, and ammoniac. Theſe ſalts have not yet been examined with ſufficient care to enable us to give here a particular account of them. M. Eloy Bourſier de Clervaux has communicated, in the Lectures of Che-

miſtry of Dijon, ſome experiments very ſuitable to determine the elective attractions of the pyro-ligneous acid. Calcareous and barytic earths adhere to it with greater obſtinacy than the alkalis; lime has a ſtronger affinity with it than barytes; and magneſia a ſtronger than ammoniac: and even theſe affinities may ſerve to diſtinguiſh it from moſt other vegetable acids. It acts alſo upon many of the metals, and diſſolves moſt of their oxides.

All kinds of wood, it appears, would afford the ſame acid by diſtillation; for box, birch, and beech, agree in affording one acid. But much inquiry, and many experiments, are neceſſary, before we can be fully acquainted with the characteriſtic properties of this acid.

§ IV. *Of Vegetable Acids, formed by the Nitric Acid.*

BERGMAN has proved, that the nitric acid converts ſugar into an acid, which, being at firſt thought peculiar and different from all others, was therefore called the ſaccharine acid. Scheele has ſhown this ſalt to be preciſely the ſame with that which is in part neutralized by potaſh, in ſalt of ſorrel: this very ſalt is therefore in every reſpect the ſame with the oxalic acid. Several modern chemiſts, and eſpecially M. Berthollet, have proved, that almoſt all animal and vegetable matters afford this acid, when treated with the acid of nitre. It is therefore certain, that the baſe or radical principle of the oxalic acid exiſts in a great many bodies, and, in general, in all bodies which have been formed by vegetation, or the functions of animal life. The nitric acid acts in an equal and uniform manner on all ſuch ſub-

ſtances;

ſtances; it always gives up to them either more or leſs of its oxigene, and paſſes into the ſtate of nitrous acid, nitrous gas, or even azotic gas, according as it is deprived of a greater or a leſs proportion of its oxigene. As the baſe, or radical principle of the oxalic acid, is more or leſs copious in the various organic matters in which it is found; theſe matters afford more or leſs of this acid, when treated with nitric acid. At the ſame time, when the acid of nitre is decompoſed by organic ſubſtances, together with nitrous or azotic gas, there is alſo diſengaged a certain quantity of carbonic acid gas, which proves the organic matter to have loſt a part of its carbonaceous ſubſtance, and at the ſame time ſhews the oxalic acid, thus produced, to contain leſs of that principle than the ſubſtance from which it is obtained. Since a number of vegetable acids, particularly the tartareous acid, &c. paſs into the ſtate of oxalic acid, in conſequence of being expoſed to the action of nitrous acid; and ſince carbonic acid is diſengaged while this change takes place; it follows plainly, therefore, that all the vegetable acids have the ſame radical principle, and differ only in their proportions of oxigene.

In the *Nouvelles de la Republique de Lettres* for the year 1785, No. 42. and 44. it was related, that M. Koſegarten, by diſtilling nitric acid on camphor, eight times ſucceſſively, had obtained from that matter a concrete acid, in parallelipiped cryſtals, of bitter taſte, and capable of reddening the tincture of violets and turnſol. That ſalt, according to this chemiſt, differs from oxalic acid, as being incapable of ſeparating lime from the muriatic acid. With potaſh, it forms a ſalt in regular hexagons; with ſoda, a ſalt in irregular cryſtals; with ammoniac,

ammoniac, prismatic, or needled crystals; with magnesia, a soluble, pulverulent salt. It dissolves copper, iron, bismuth, zinc, arsenic, and cobalt. But these facts, which have not yet received confirmation, are not sufficient to enable us to enter into a minute account of the properties of this acid, which is, perhaps, nothing but a particular modification of some one of those of which we have already spoken. And if farther experiments on this acid shall discover it to possess peculiar properties, different from those of the other acids, its nature and characteristic properties must then be examined under the name of the camphoric acid, and its neutral salts will be called *camphorates*.

M. Brugnatelli discovered, in the year 1787, that cork, on which he distilled four times its own weight of nitrous acid, left a yellowish mass, thick, acid, soluble in water, and of a sour, or rather a bitter taste. This acid is not susceptible of crystallization; when evaporated by a strong heat, it takes the form of a viscous mass, like wax, which is so soft that it may be moulded with the fingers. It is soluble in alcohol; on burning coals, it is reduced to a coal without inflammation; with earths and alkalis, it forms deliquescent salts, many of which crystallize: lastly, it has as strong an affinity with lime as the oxalic acid, and forms with that earth a salt that is not soluble in water, but may be dissolved in muriatic acid. Without presuming to speak decisively of the peculiar nature of this acid, M. Brugnatelli appears, however, to think it different from the oxalic acid. Future experiments must determine whether this be really a peculiar acid meriting a separate examination; and we must, in the same manner, leave the particular nature

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of that which has been discovered by Messrs Proust and Angulo, in the neighbourhood of Madrid, on the surfaces of grey pease, in vesiculæ at the extremity of the hairs of that leguminous plant, equally undetermined.

Thus we have given an account of all known vegetable acids. We have still, however, to treat of those which are formed by fermentation. But as the chief, nay, the only one of these acids that is known, is produced in consequence of an alteration taking place on liquors that are already fermented, we will give its history immediately after that of spirituous fermentation, and its product.

CHAP. VIII.

Of Saccharine Matter, Gums, and Mucilages.

THE ſaccharine matter, which many chemiſts think to be a ſort of eſſential ſalt, is found in a great many vegetables, and is to be conſidered as one of their immediate principles.—The maple, the birch, the red beet, the parſnip, the grape, wheat, &c. are found to contain it. Margraff extracted it from moſt of theſe vegetables. The petals of many flowers, and the nectaria placed in thoſe organs, prepare a principle of this kind.

The ſugar-cane, *arundo ſaccharifera*, is the plant which contains the moſt of it, and from which it is extracted with the greateſt advantage. The ſugar-canes are cruſhed to pieces between two iron cylinders, in a perpendicular poſition. The expreſſed juice falls upon a plain ſurface underneath; and is called *melaſſes*. It runs off this ſurface into a boiler with aſhes and lime, where it is boiled and ſkimmed; and, in the ſame manner, it is ſucceſſively boiled and ſkimmed in three other boilers; and, after undergoing theſe boilings, it receives the

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name of ſyrup. It is after this boiled anew, by a ſtrong heat, and for a conſiderable time, with lime and alum. After being ſufficiently boiled and concentrated, it is poured into a veſſel called *the cooler*. When it is ſo cool that the finger may be dipped in it without injury, it is poured into large barrels ſtanding over ciſterns, and the bottoms of which are perforated with holes ſtopped with canes. In the barrels, the ſyrup takes the form of a ſolid maſs, part of it running off into the ciſterns. The ſugar, when thus rendered concrete, is yellow and unctuous; it is now called *muſcovado*. In the ſugar-iſlands, it is refined by boiling it, and then pouring it fluid into inverted cones of earthen ware, called pans. That part which cannot be rendered concrete runs through a hole in each of the pans, into a pot placed below; it is called *coarſe ſyrup*. The baſe of the ſugar-loaf is taken away, and white ſugar in powder put into its place, and preſſed well down: The whole is then covered with pure moiſt clay. The water of the clay filtrates through the ſugar, carrying off with it a portion of the mother-water of the ſugar, which runs out by the holes in the pans, and is received into new pots. This is called *fine ſyrup*, as being purer than the former. A ſecond layer of clay is laid on when the firſt becomes dry, and the water filtrates through, a ſecond time: When the water contained in the ſecond layer of clay is drained off, the loaves are removed into a ſtove to dry. At the end of eight or ten days theſe loaves are broken, and ſent into Europe in the form of brown ſugar, which is here refined into ſugar of different qualities.

The refining of ſugar is accompliſhed by b [illegible] it in

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lime-water, and with bullock's blood, ſkimming it two or three times, filtrating the liquor, and running it in pans, to give it the ſhape of loaves. Theſe loaves are then coated over with wet clay, the water of which is ſuffered to filtrate through them. The filtration is repeated with freſh clay, till the ſugar become ſufficiently white. The loaves are then removed into a ſtove, and at the end of eight days are wrapped up in a paper for ſale. The *ſyrup* which cannot be cryſtallized is called *molaſſes*.

Chemiſts have univerſally been of opinion, that theſe different operations ſeparated from ſugar a fat matter, and thereby rendered it ſuſceptible of cryſtallization. Bergman thinks, that the uſe which the lime ſerves is, to carry off the exceſs of acid, which hinders it from taking a ſolid form. The acid can be no other than the pyro-mucous acid which is formed by heat, as we have related in the foregoing chapter. As the liquor is expoſed, during the operation, to a violent evaporation, it becomes a granulated, irregular maſs, agreeably to what has been already obſerved of ſulphate of zinc.

Sugar is a ſubſtance in ſome meaſure of an intermediate nature between eſſential ſalts and mucilages. It cryſtallizes in truncated hexahædral priſms. In this ſtate it is called *ſugar-candy*. It affords, by diſtillation, water, pyro-mucous acid, and a few drops of empyreumatic oil. There is at the ſame time diſengaged from it a conſiderable quantity of carbonic acid gas, and of hydrogenous gas, with coal diſſolved in it. The reſidue is a ſpongy light coal, containing a little carbonate of potaſh.

Sugar is inflammable: When laid on burning coals, it melts and ſwells; it exhales a very pungent acid vapour;

pour; it takes a brown-yellow colour, in consequence of which it recieves the name of *caramel.* It dissolves very readily in water. It communicates to it a considerable consistency, forming with it a sort of saccharine mucilage, which has received the name of *syrup.* This syrup, when diluted in water, is susceptible of fermentation; it may even be converted into a vinous liquor, and alcohol distilled from it.

Bergman prepared from all the different saccharine matters, especially from sugar,—oxalic acid, by means of the nitric acid. To obtain that acid from these matters, put into a retort one part of sugar in powder, with six of nitric acid: Expose the mixture to a moderate heat; continue the evaporation for some time after red vapours cease to pass; leave the solution to cool; and it then precipitates white needled or prismatic crystals, which are concrete oxalic acid.

Sugar is very much used.—It is an article of food, which, when taken in too large a quantity, heats the animal system. It is much used in pharmacy, being the basis of syrups, lozenges, and some other preparations. It contributes to dissolve and suspend in water, resins, oils, &c. It serves to preserve fruits reduced to jelly. It may be even considered as a medicine; for it is incisive, aperitive, and, in a slight degree, tonic and stimulant: And accordingly there are some instances related, in which disorders arising from obstructions have been cured by the continued use of sugar.

There are some juices of plants which have a taste of sugar. Manna and nectar are of this kind. Manna is obtained from the leaves of fir, oak, juniper, &c. and maple-trees, &c. The ash, which is very plenteous in

Calabria

Calabria and Sicily, affords that which is commonly fold. It runs naturally from thofe trees, but is obtained in ftill greater abundance by making notches in the bark of the tree.—That which is received on chips of wood, or fmall fticks introduced into artificial apertures in the trees, takes the form of hollow ftalactites, and is called *manna in tears*. *Manna in flakes* runs down the bark, and contains fome impurities. The inferior unctuous fort contains many extraneous matters, and is formed from the refufe pieces of the two former. It is always humid, and frequently altered. The tafte of manna is mild and infipid: That which the larch-tree that abounds in Dauphiny affords, and that of the alhagi, which grows in Perfia, around Mount Tauris, are not in ufe; the latter bears the name of *tereniabin*.—Manna is foluble in water; it affords, by diftillation, the fame products as fugar. There is extracted from it, by means of lime and white of eggs, a matter refembling fugar, which, when treated with the nitric acid, affords concrete oxalic acid.

It is given as a purgative, in dozes of from one to two or three ounces; or, when it is given as a difcuffive, a few drachms of it are diluted in a large proportion of water.

Another fort of proper juice is that called *gum* or *mucilage*. This fubftance is very plenteous in the vegetable kingdom. It is found in a great many roots: Young ftems and leaves, immediately after their appearance, contain a good deal of it. This principle may be known by its vifcous adhefive property. In the feafon when the juice is moft copious, it runs naturally down the bark of trees, and thickens into gum on the furface.

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The gum is ſoluble in water, to which it communicates a thick viſcid conſiſtency. This ſolution, known by the name of *mucilage*, becomes, when evaporated, dry, tranſparent, and friable.

Gum burns without emitting any perceptible flame. It melts and ſwells upon coals. It affords, by diſtillation, a good deal of water and pyro-mucous acid, a little thick brown oil, and carbonic acid gas, mixed with hydrogenous gas: The reſidual coal is very bulky, and contains a little carbonate of potaſh.

We know of three ſorts of gum that are uſed in medicine, and in the arts.

1. The gum of the apricot, the pear, and the plum tree, &c. It is either white, yellow, or reddiſh; the beſt of this ſort of gum may be applied to the ſame purpoſes as the other gums. A kind of gummy juice, of a beautiful orange-colour, flows from the elm; conſiderable quantities of it are ſometimes found on the bark of the tree. I have found this gum to poſſeſs the properties of inſipidity, inſolubility, viſcidity, with the other characteriſtics belonging to ſuch juices.

2. Gum Arabic, which runs from the acacia in Egypt and Arabia. Gum Senegal is of the ſame kind; it is uſed in medicine as a mitigating and relaxing remedy. Crayons, and ſome other ſuch compoſitions, are indebted to it for their conſiſtency. It is uſed in various arts.

3. Gum Adraganth, which flows from the adraganth of Crete; Aſtragalis Tragacantha. It is adminiſtered in the ... ſes as Gum Arabic; the ſolution of it is ſome... icker than the ſolution of Gum Arabic; it ſoon

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depofites vifcid flakes, and requires more water to diffolve it.

Mucilages, of the fame nature with gums, are obtained from various plants. The roots of mallows, marfh-mallows, the greater comfrey, the bark of elm, lintfeed, the feeds of quinces, &c. afford, by maceration in water, vifcous fluids; which, when evaporated to drynefs, afford real gums. In medicine, decoctions of thefe plants are ufed inftead of folutions of gums.

All of thefe matters, chemically confidered, appear at firft view to be nearly fimple bodies; for chemical operations often offer to our obfervation fubftances of a gelatinous form, much like that of gums and mucilages; yet, from thefe products of vegetation, which appear to form a fort of excrementitious humour, are extracted water, liquid pyro-mucous acid, carbonic acid, an oily principle, and fixed alkali united to a coaly refidue. This refidue likewife contains a fixed earth, the nature of which is ftill unknown.

When mucilages and gums are treated with nitric acid, and its action affifted by heat, they afford oxalic acid in cryftals. They contain therefore the oily or radical principle, which, in combination with oxigene, conftitutes this acid.

This analogy between mucilage and faccharine matter is farther obfervable in that the fmell of burnt gum is much the fame with that of caramel—that the products which both afford by diftillation are of a fimilar nature—and that the bulk and levity of the refidual coal are the fame in both. Some of thofe fruits which become faccharine, fuch as apricots, pears, &c. exfude, before they become ripe, a real gum. That fort of dry mucilage which

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we are hereafter to examine under the name of *amylaceous fecula*, ſeems to be converted into ſaccharine matter by germination. Theſe facts, and many others which might be joined with theſe, ſhew that there is a near relation between ſugar and gum. Perhaps the inſipid or gummy mucilage paſſes by a ſort of fermentation into the ſtate of a ſaccharine body. Were this an aſcertained fact, this fermentation would come in order before that which Boerhaave has called *ſpirituous fermentation*; and muſt conſtantly precede it, both in the natural proceſs of vegetation, and in the operations which art employs to produce the ſaccharine taſte in barley, &c.

CHAP. IX.

Of Oils of a fixed Nature, that are extracted by Expression.

OILS are proper juices, of a fat, unctuous nature, either fluid or solid, not soluble in water, liable to burn with flame, volatile in various degrees: They are contained in the proper vessels, or in particular vesiculæ. These bodies are found existing in two states in vegetables: They are either combined with other principles, as in extracts, mucilage, &c. or they are free, and not united with any other principle. These latter oily juices are those of which we are here to speak.

Chemists have supposed the existence of a simple oily principle, as well as of a primitive salt. This oily principle, combined with different substances, and modified by those combinations, constituted, according to them, the various sorts of oils that were obtained by analysing vegetables. The characters which they ascribed to that simple primitive oil, were, great fluidity, an high degree of volatility, privation of colour and smell:—It burns

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with flame and ſmoke:—It did not combine with water: —It was thought to conſiſt of water and an acid combined with an earth and *phlogiſton*. It is certain that oils, when decompoſed, always afford a ſmall quantity of acid, and a good deal of hydrogenous gas: earth conſtitutes but a very ſmall part of them, for they leave but very little fixed carbonaceous reſidue. This notion of the oily principle deſerves to be viewed only in the light of an hypotheſis.

Oils are never formed by any but organic beings; and ſuch bodies in the mineral kingdom as are of an oily nature, always owe their origin to the action of vegetable or animal life. It is even highly probable, that vegetables are the only bodies in which oils are formed; and that they paſs without alteration from vegetable into animal bodies.

The oily juices of vegetables are diſtinguiſhed into fixed oils and volatile oils.

Fixed oils, called alſo *fat oils*, *ſweet oils*, *oils by expreſſion*, are very unctuous: they have generally a mild and inſipid taſte, and no ſmell; the heat requiſite to volatilize them is above that of boiling water; and they never take fire till they are brought to that degree of heat which is requiſite to volatilize them.—It is for this purpoſe the wick uſed in burning fixed oil in lamps is employed; it heats the oil to volatilization.

Moſt fixed oils are fluid, and require no conſiderable degree of cold to render them ſolid: Others, again, loſe their fluidity by the ſlighteſt cold; and, laſtly, there are others always ſolid: Theſe laſt are called, but very improperly, *vegetable butters*.

Fixed oils never flow from the ſurfaces of vegetables; They are contained in the kernels, the pippins, and emulſive ſeeds. They are extracted by bruiſing the little cells in which they are contained; that is, by pounding and ſqueezing.

Fixed oils, when expoſed to the air, are altered, and become rancid; their acid is liberated; they loſe the properties which they poſſeſſed, and acquire others, in conſequence of which they are nearly aſſimilated to volatile oils. Water and alcohol carry off the acid, and thus deſtroy their rank taſte, but never reſtore them to their primary ſtate. M. Berthollet has diſcovered, that fat oils, when expoſed to air, by being thinly ſpread over the ſurface of water, become thick, and aſſume pretty much the ſame appearance with wax. It is at preſent known as an undeniable fact, that this thickening of oils is owing to their abſorbing oxigene from the atmoſphere; for all ſubſtances that contain this principle, and reſign it to fixed oils,—as for inſtance, many of the acids, eſpecially the oxigenated muriatic acid, and metallic oxides,—thicken fixed oils, and reduce them to a ſtate in which they reſemble wax.

Fixed oils afford by diſtillation a little water, containing a very acrid pungent acid, ſome light oil, a thick oil, and a large quantity of hydrogenous gas, mixed with carbonic acid: They leave but very little reſidual coal. By diſtilling theſe products a ſecond time, pure ſebacic acid is obtained, of which we will have occaſion to ſpeak in the animal kingdom, and ſome oil, ſtill lighter than what was before obtained.—This oil is improperly called *philoſophers oil.* The alchemiſts prepared it by diſtilling ſeveral times ſucceſſively, a brick impregnated with fixed

oil.

oil. It is not perfectly known how far this decompoſition may be carried: formerly, indeed, it was ſaid that a fixed oil might be reduced to a free inflammable principle; into water, acid, air, and earth.

Cold water effects no alteration on fat oils; it purifies them by carrying off a part of their mucilage, which is likewiſe precipitated when they are ſubmitted to combuſtion, and is the principle that renders them ſuſceptible of fermentation, and liable to become rancid.—It is well known, that water caſt upon theſe oils, when burning, inſtead of quenching, cauſes them to burn with new violence: the reaſon of which is, that the water, being decompoſed, ſupplies oxigene to the oil, and at the ſame time gives out a good deal of hydrogenous gas. When the vapour which proceeds from fixed oil in combuſtion, is collected into a chimney terminating in a worm-pipe, a conſiderable quantity of water is obtained; which proves this immediate principle of vegetables to contain hydrogene.

Fixed oils do not combine with ſiliceous earth: With clay, they form a ſoft paſte, which is employed in chemical manipulations, under the name of *fat lute*.

They combine, by particular proceſſes, with magneſia, and are thereby reduced to a ſaponaceous ſtate.

Lime combines with them, but not in a very diſcernible manner, when the combination is immediate. Pure alkalis combine eaſily with fat oils, producing by this combination what is called *ſoap*.

In making ſoap, oil of olives or ſweet almonds is triturated with a concentrated lixivium of ſoda, rendered cauſtic by lime; and this preparation is known by the name of *ſoap-lye*.—In the courſe of a few days, the mix-

ture becomes thick, and forms medicinal ſoap. Common ſoap is prepared by boiling the lixivium with altered oil; it is then white. Green ſoap is made up of the refuſe of olives and potaſh.

Soap diſſolves in pure water: Heat decompoſes it, diſengaging from it phlegm, oil, and ammoniac, formed in conſequence of the decompoſition of the fixed alkali and the oil; the coaly reſidue contains a good deal of fixed alkali. This artificial compoſition of ammoniac ſeems to prove, that there is azote in the fixed alkali, which re-acts upon the hydrogene of the oil.

Lime-water decompoſes ſoap, as has been remarked by M. Thouvenel; an inſoluble calcareous ſoap is then formed, and depoſited in ſmall lumps. Acids, poured on ſoap, diſengage the oil, ſomewhat altered.

Ammoniac does not eaſily combine with fixed oils: however, by long trituration, the mixture acquires ſome degree of conſiſtency, and becomes opaque.

Fixed oils combine with weak acids to form peculiar ſoaps. Meſſrs Achard, Cornette, and Macquer, have examined theſe compounds. M. Achard formed them by pouring ſlowly a quantity of concentrated ſulphuric acid upon the fixed oil. By continued trituration, this mixture is formed into a brown maſs, ſoluble in water and alcohol. The oil obtained from it by the intervention of alkalis, is always more or leſs concrete, as well as that obtained by diſtillation. Macquer adviſes to prepare this ſoap by pouring acid on the oil; but he informs us, that an acid ſoap, formed in this manner, is ſcarce ſoluble in water; that which is prepared of concentrated ſulphuric acid, triturated with common alkaline ſoap, is more ſoluble. The concentrated ſul-

phuric

phuric acid blackens fixed oils, and aſſimilates them to bitumens. This phenomenon ſeems to be produced by the re-action of the hydrogene of the oil on the oxigene of the acid.

The fuming nitrous acid blackens fixed oils inſtantaneouſly, and cauſes ſuch as are of a dry nature to kindle and emit a flame. Thoſe, again, which cannot be ſo readily dried, require to kindle them a mixture of this acid with the acid of ſulphur, as has been ſhown by Rouelle the elder, in his Memoir on the Inflammation of Oils. *Academy, year* 1747.

The muriatic and the carbonic acids act with but little ſtrength on fixed oils.—The former of theſe, however, in a concentrated ſtate, combines with them to a certain degree, according to M. Cornette. The oxigenated muriatic acid thickens them a good deal, and ſeems to make them paſs, by the abſorption of its oxigene, into a ſtate in which they bear a great reſemblance to wax.

We know nothing of the action of the other acids on fixed oils. It appears that they do not combine with neutral ſalts. Several of theſe, and eſpecially all calcareous ſalts, decompoſe alkaline ſoap. In this inſtance of decompoſition, particularly when ſulphate of lime, or of magneſia, which is often found in union with waters, decompoſes this ſoap, the ſulphuric acid combines with the fixed alkali of the ſoap, and thereby forms ſulphate of ſoda; the lime or magneſia combines with the oil, and produces a ſort of ſoap that is ſcarce ſoluble, and ſwims in whitiſh lumps on the ſurface of the water. This is the cauſe of the common appearance produced by hard waters, which curdle ſoap, but do not diſſolve it.

2 The

The action of hydrogenous gas on fixed oils has not yet been examined.

These oils dissolve sulphur, when their action is assisted by a boiling heat. The solution is of a dark red colour, inclining to brown. It has a very fœtid smell. It deposites, by degrees, sulphur in crystals. On distilling this combination, the sulphur is volatilized, being so completely dissolved in the hydrogenous gas that is disengaged from the oil, that not an atom of it is to be afterwards found. This fact deserves to be more particularly inquired into. There is also a little sulphureous gas obtained by this decomposition.

Fixed oils seem not to be susceptible of combination with pure metallic substances, excepting iron and copper, upon whch they act in a sufficiently distinct manner. But they combine with metallic oxides, and form with them thick concrete combinations, of a soapy appearance, as is observable in the preparation of unguents and plasters. These preparations have not been yet chemically examined: only we know, that some metallic oxides are reduced in the making up of plasters; as, for instance, oxide of copper in the Divine Plaster, and litharge, or oxide of lead, in the ointment *de la mere.* In the assaying of metals, fixed oils are employed to reduce the metallic oxides. M. Berthollet has given an ingenious and simple process for effecting instantaneously a real combination between fixed oil and any metallic oxide, that is, for preparing a metallic soap. It consists in pouring a metallic solution into a solution of common soap. The acid of the metallic solution combines with the fixed alkali of the soap; and the metallic oxide is then precipitated in union with the oil, to which it

communicates a colour. In this manner, ſoap of a beautiful green colour may be prepared with ſulphate of copper; and with ſulphate of iron, a clear deep brown ſoap. Theſe compounds might be very uſeful in painting.

Scheele has diſcovered, that when oil of ſweet almonds, olives, rapeſeed, or lintſeed, is combined with oxide of lead, with the addition of a little water, there is a matter ſeparated from the oil, which ſwims on the ſurface of the liquor, and to which he has given the name of *the mild principle.* On evaporating this ſupernatant water, the principle diſſolved in it cauſes it to take the conſiſtency of ſyrup; when expoſed to a ſtrong heat, it takes fire: one part is volatilized, in diſtillation, without burning: the coal which it leaves is light: it does not cryſtallize; nor does it ſeem to be ſuſceptible of fermentation. Nitric acid diſtilled on this matter, four times ſucceſſively, changes it into oxalic acid. This mild principle of Scheele's appears to be a ſort of mucilage.

Fixed oils diſſolve bitumens, particularly amber; but they muſt be aſſiſted by the action of heat, in order to effect this ſolution. They form a ſort of greaſy varniſh, which does not readily become dry.

Fat oils may be diſtinguiſhed into three genera:

To the *firſt* claſs belong ſuch pure fixed oils as are fixed by cold, are ſlowly thickened, form ſoaps with acids, and are kindled only by a mixture of the acids of ſulphur and of nitre. Such are,

1. Oil of olives, obtained by bruiſing that fruit between two millſtones, and preſſing it in bags made of ruſhes. That which runs firſt is called *virgin oil;* that which

which is obtained from mark ſprinkled with water is not ſo pure, and depoſites a lee; that obtained from unripe olives, is the *oleum omphacinum* of the ancients. Oil of olives freezes at 10° degrees under Zero in Reaumur's thermometer, or 10½ above that point in Fahrenheit's, and will ſtand about twelve years without becoming rancid.

2. Oil of ſweet almonds, extracted without the application of heat, becomes very ſoon rancid: it freezes at 6° under 0 in Reaumur's ſcale, or 17½ of Fahrenheit's.

3. Oil of rapſeed, obtained from the ſeed of a kind of cabbage called *colſa*.

4. Oil of ben, extracted from the ben-nut of Egypt and Arabia. It is very acrid, and deſtitute of ſmell. It freezes very eaſily.

The ſecond genus comprehends oils ſubject to become dry, which are very eaſily rendered thick, are not fixed by the action of cold, are kindled by the nitrous acid alone, and form, with ſulphuric acid, a ſort of reſin, Such are,

1. Lintſeed-oil, obtained by preſſure from lintſeed roaſted. It is uſed for oily varniſhes, and in painting.

2. Oil of nuts, applied to the ſame uſes.

3. Oil of carnations, or poppy ſeed; which, as has been fully proved by the Abbé Rozier, is not at all narcotic.

4. Oil of hempſeed, which is very drying.

Under the third genus, we comprehend concrete fixed oils, or *vegetable butters*; among which we may diſtinguiſh the following:

1. Butter of cacao, extracted from the cacao-nut.—There are four sorts of cacao; the large and the small caracca, the berbice, and that of the Islands. This butter is extracted from the nut boiling in water; it is purified by melting it by a very moderate heat.

2. The coco affords a similar butter.

3. Vegetable wax is of the same nature, only more solid. It is the production of China. It is there made into yellow, white, or green candles, the colour varying with the manner in which the wax is extracted. The catkins of birch and poplar afford a small quantity of a similar wax.—That of Louisiana is more plenteous. M. Berthollet easily whitens it with oxigenated muriatic acid.

Fixed oils are much used in the arts, and in medicine, and are applied to various purposes. In the latter they are used as softening, relaxing, calming, and laxative medicines. Some of them are even purgative; as, for instance, the *Oleum Ricini*, which has been found to destroy the tænia, or solitary worm, and cause it to be evacuated. They enter into a great many compound medicines, such as balsams, unguents, and plasters.—Lastly, they are sometimes used as seasoning, or food, on account of their agreeable taste, and the mucilage which they contain.

CHAP.

CHAP. X.

Of Volatile Oils.

VOLATILE or *essential* oils are distinguished from fixed oils by the following peculiar properties.—Their smell is strong and aromatic: They are so volatile, that they may be distilled by the heat of boiling water: Their taste is very acrid: They are much more combustible than the other class of oils.

These oils are found to exist in almost all odorous plants. They are contained either in the whole plant, as in the angelica of Bohemia, or only in the root of the plant, as in starwort, the iris, white dittany, and kidney; or in the stem, as in sandal, sassafras, and pine-wood; or in the bark, as in cinnamon. Sometimes it is confined to the leaves, as in balm, peppermint, wormwood, &c. In other plants, it is found in the calices of the flowers: Of this kind are the rose and lavender; the petals of camomile and the orange-flower are filled with it. It is, at other times, fixed in the fruits, as in cubebs, pepper, and juniper-berries. Lastly, A number of

of vegetables contain it in the ſeed; ſuch as nutmeg, aniſe, fennel, and the many umbelliferous plants.

Theſe oils differ from one another, 1. In their quantity, which varies according to the ſtate or age of the plant: 2. In conſiſtency; ſome are very fluid, ſuch as thoſe of lavender, rue, &c.; ſome congeal by cold, ſuch as oil of aniſe, and fennel; others are always concrete, of which kind are the oils of roſes, parſley, kidney-wort, and ſtar-wort: 3. In colour; ſome are deſtitute of colour; others, ſuch as oil of lavender, are of a pale yellow; or a dark yellow, as oil of cinnamon; or blue, as oil of camomile; or ſea-green, as oil of St John's-wort; or green, as oil of parſley: 4. In gravity; ſome ſwim on the ſurface of water, moſt of thoſe, indeed, that are produced in temperate countries; others ſink to the bottom of that fluid, as oil of ſaſſafras, of carraway-ſeeds, and moſt oils of this kind from hot countries; this property, however, is not conſtant with reſpect to climate, for the eſſential oils of pepper, nutmegs, and mace, &c. are lighter than water: 5. In taſte and ſmell; the taſte of an eſſential oil is often very different from that of the plant from which it was extracted; pepper, for inſtance, affords, a mild oil, and oil of wormwood is not bitter.

Volatile oils are extracted, 1. By preſſure, from codra, bergamot, lemons, oranges, &c.; this is called *eſſence:* 2. By diſtillation; the plant is put into the cucurbite of a copper alembic, with water; the water is boiled, and the oil paſſes together with the fluid, and gathers above it in a receiver prepared for their reception.

Volatile oils are adulterated either by fixed oils, which is detected by their ſtaining paper; or by oil of tur-

pentine,

penting, which may be diſcovered by the ſtrong ſmell peculiar to turpentine, which always remains after the eſſential oil is evaporated; or by alcohol, and then water, by rendering the mixture turbid, detects the alteration produced by this ſubſtance.

Volatile oils loſe their ſmell by a moderate heat. As they are ſo very volatile, fire does not decompoſe them. When heated in cloſe veſſels, they give out a large proportion of hydrogenous gas. When heated in contact with air, they take fire ſpeedily, and exhale a very thick ſmoke, which is condenſed into a very fine, light, carbonaceous matter: They leave but very little coaly reſidue after inflammation, being ſo volatile, that the carbonaceous matter is carried off along with the part that is volatilized.

When expoſed to the air, they become thick, and, in proceſs of time, are converted into reſins. They depoſite needled cryſtals, like thoſe of ſublimated camphire. Geoffroy the younger obſerved theſe cryſtals in the volatile oils of mother-wort, marjoram, and turpentine. Their ſmell, he informs us, is much the ſame with that of camphire. *Acad.* 1721, *page* 163.

They combine with ſome difficulty with lime and alkalis; and form with theſe ſubſtances imperfect ſoaps, to which we give the name of *ſaponulæ*: Acids alter them; the concentrated ſulphuric acid changes them into bitumens; when weak, it forms with them a ſort of ſoap. The nitrous acid inflames them; the muriatic acid reduces them to a ſaponaceous ſtate; the oxigenated muriatic acid thickens them.

They act not upon neutral ſalts.

They

They combine very eafily with fulphur, with which they form compounds that are called *balfams of fulphur*, in which the fulphur is fo divided that it cannot be extracted, but is feparated by heat in the form of fulphurated hydrogenous gas.

Mucilages and fugar render them foluble in water. They are ufed in medicine as cordials, ftimulants, antifpafmodics, &c. Externally applied, they are powerful antifeptics, and ftop the progrefs of caries in the bones.

CHAP. VIII.

Of the Camphorate Principle.

CAMPHOR is a white matter, concrete, cryſtalline, and of a ſtrong taſte and ſmell; in ſome of its properties nearly allied to volatile oils, but widely diſtinguiſhed from them by others.

Chemiſts have, from a great variety of obſervations, concluded camphor to be an immediate principle of vegetables, which, they think, exiſts in all highly odorous plants that contain volatile oil. It has, in fact, been obtained from the roots of the cinnamon tree, zedoary, thyme, roſemary, ſage, and many other labiated plants, either by diſtillation or decoction, as has been obſerved by Cartheuſer and Neumann. But the quantity of the camphor thus obtained is very ſmall, and it always retains a ſmell of the plant from which it was extracted. This ſingular ſubſtance appears to be combined with the volatile oils of theſe vegetables, as thoſe oils have been obſerved by Geoffroy to depoſite needles of camphor. I have ſeen, in the poſſeſſion of M. Joſſe, apothecary at Paris,

Paris, true camphor extracted from the root of elecampane. Lorry thought camphor a very general principle in vegetables, and placed its aromatic flavour at the head of a class of very powerful odours, the effects of which on the animal œconomy well merit the attention of physicians. M. Proust has published a Dissertation, in which he describes a process for obtaining camphor in considerable quantity from the oils of several aromatic plants that grow in Mureil.

The camphor used in medicine is extracted from a sort of bay-tree that grows in China, Japan, and in the isles of Borneo, Sumatra, Ceylon, &c. The tree which produces it, often contains it in such abundance, that very large and pure tears of camphor may be obtained from it solely by splitting the wood. It is commonly, however, extracted by distillation. The roots, or other parts of the tree, are put into an iron alembic, with water, covered over with a capital, containing ropes of rice-straw, and thus exposed to heat. The camphor is sublimated in small greyish grains; and these again unite into larger pieces. This crude camphor is impure. The Dutch purify it by sublimating it in a sort of balloon, and adding an ounce of lime to the pound of crude camphor.

Camphor is much more volatile than the essential oils; for the gentlest heat is sufficient to sublimate it. It crystallizes in hexagonal plates, with a stem in the middle. When a strong heat is applied, it melts before volatilizing. It does not appear to be decomposable by this means: however, when distilled a number of times successively, it affords a reddish phlegm, evidently of an acid nature; and this shews, that if the process

were carried farther, its nature might at length be altered. The temperature of summer is sufficient to volatilize camphor. When exposed to the air, it is entirely dissipated and lost; when inclosed in close vessels, it is sublimated in hexagonal pyramids, or in polygon crystals, which were, in the year 1756, observed and described by Romieu. It exhales a strong smell, too strong indeed for the nerves of some people to bear. It takes fire very easily, burns with a good deal of smoke, and leaves no coaly residue.

It is not soluble in water; it will, however, communicate its smell to water: it burns on its surface. Romieu has observed, that small pieces of camphor, one third, or one fourth of a line in diameter, when put into a glass of pure water, move round, till they are at length dissolved in about the space of half an hour. He suspects this motion to be an effect of electricity; and observes, that it ceases when the water is touched with any body that can act the part of a conductor, such as iron-wire; and that, on the contrary, it still continues, though the water be touched with an insulating body, such as glass, resin, sulphur, &c.

Earths, salino-terrene substances, and alkalis, are incapable of acting on camphor. We must observe, however, that the power of caustic alkalis on this substance, has not yet been brought to trial.

Acids, when concentrated, dissolve camphor. The sulphuric acid dissolves it, with the help of heat: the solution is red. The nitric acid dissolves it slowly: this solution is yellow. As it swims over the acid in the same way as oils, it has been improperly called *oil of camphor*. M. Kosegarten has discovered, as has been

taken

taken notice of in the VIIth Chapter, that the nitric acid, when distilled eight times successively upon camphor, changes into a crystallizable acid, which he thinks to be of a peculiar nature.

The muriatic acid gas dissolves camphor; so likewise do the sulphureous acid gas, and the fluoric acid gas. When water is poured into these solutions, they become turbid; the camphor is separated in flakes, which swim on the surface of the liquor, and appear to have suffered no alteration. Alkalis, the salino-terrene substances, and metallic matters likewise precipitate these solutions.

Neutral salts act not upon camphor. We know not in what manner sulphur and bitumens act upon this substance; but they are probably capable of combining with it.

The fixed and the volatile oils dissolve camphor with the help of heat. These solutions, when cooled, deposite, by degrees, crystals in a vegetative form, similar to those that are formed in solutions of ammoniacal muriate; that is, consisting of a stalk, with very fine filaments extending from it horizontally. These filaments, which in their disposition resemble the beard of a feather, exhibit a very beautiful and regular appearance, when viewed through a microscope. We owe this fine fact to Romieu, (*Academy* 1756, *page* 448.) The solution of camphor in alcohol, which is much better known, and much more in use than the preceding solution, was observed by the same chemist to afford, by a particular process, a species of crystallization somewhat different.

Camphor is one of the most potent remedies which medicine employs. It dispels inflammatory tumours in a

very ſhort time. It is uſed as an antiſpaſmodic and antiſeptic medicine, in infectious diſtempers, the malignant fever, and all diſeaſes in general that are attended with affections of the nerves and putridity. In France, it is given only in doſes of a few grains: In England and Germany, they go ſo far as to give it in doſes of ſeveral drachms a-day. It is alſo worthy of being mentioned, that camphor alleviates burnings, and pains in the urinary paſſages, ſo ſpeedily often as might tempt the patient to think his relief the effect of enchantment. It is given either triturated with the yolks of eggs, ſugar, and gums, or in the ſtate of oil of camphor, and always in certain drinks prepared for the purpoſe. Surgeons apply camphorated ſpirit of wine, of the compoſition of which we ſhall hereafter give an account, to external gangrenes; and the liquor often puts a ſtop to their progreſs.

CHAP.

CHAP. XII.

Of the Spiritus Rector, or the Aromatic Principle of Plants.

BOERHAAVE gives the name of *ſpiritus rector* to that principle to which plants owe their ſmell: very little, however, is as yet known concerning the properties of this ſingular ſubſtance, which, from its influence on the animal œconomy, ſo ſtrongly attracts our notice. We uſe the name *aroma*, inſtead of *ſpiritus rector*, deriving it from the well-known term *aromatic*.

The aromatous principle of plants appears to be very volatile, very fugitive, and very ſubtle; it is continually diſengaged from plants, forming around them an odorous atmoſphere, of a wider or a narrower extent. Plants differ all from one another in the quantity, the ſtrength, and the nature of their aromatous principle. Some are plenteouſly provided with this principle, and loſe it only in part when dried, ſo that it would appear to be in ſome meaſure fixed in them: of this kind are in

general all odorous woods, and all the dry and ligneous odorate parts of vegetables. In others, this principle is so fugitive and volatile, that though they be strongly odorous, they can scarce be rendered permanently so. Lastly, there are some plants which possess the odorous principle in so low a degree, that they are said to be inodorous, and their *aroma* has been distinguished as *herbaceous*.

The slightest degree of heat is sufficient to disengage the aroma of plants. To obtain it, the plant must be distilled in a *balneum-mariæ*, and its vapours received into a cold capital, which may condense, and conduct them in a fluid state into the receiver. The product is pure odoriferous water, and is known by the name of essential or distilled water. This liquor is to be considered as a solution of the odorous principle in water. That principle is more volatile than the water in which it is dissolved. This aromatic water, when heated, loses by degrees all its smell, and becomes insipid. It suffers the same alteration when exposed to air; it then deposites very light flakes, of a mucilaginous appearance, and acquires a smell of mouldiness.

The principle of smell combines with oily juices; and even appears to constitute one of the elementary principles of volatile oils; for, 1. These oils are always impregnated with it: 2. Those plants in which the principle of smell is considerably fixed, afford invariably more volatile oil than those of which the smell is very fugitive; many of which, as, for instance, those of the lily kind, often afford no volatile oil at all. The aroma of this latter class of plants, such as the tuberose and the odoriferous lily, needs to be combined with fixed oils,

oils, in order to prevent its escape. The jasmine, too, is of the same character. The flowers of these plants are put into a tin cucurbite with cotton, moistened with oil of ben; the flowers and the cotton are disposed in alternate layers; the cucurbite is then shut, and exposed to a gentle heat: The aroma, disengaged from the flowers, then combines with the oil, so as to become permanently fixed. 3. Plants that have no smell, never afford a single particle of volatile oil. 4. Vegetables, from which aromatic water has been extracted by distillation on the balneum-mariæ, no longer afford any volatile oil; at least, unless they still retain some little smell; and even in that case they afford but a very small quantity of oil. 5. Volatile oil that has lost its smell, readily regains it with all its properties, when distilled with a fresh plant of the same species with those from which it was at first extracted.

The action of saline matters on aromatic water has not yet been examined. M. Berthollet has discovered, that the oxigenated muriatic acid often destroys the smell of vegetables, and of consequence alters their aroma. It has of late been used to determine the degree or intensity of the aroma of several substances that are used as perfumes.

The nature of this principle is not the same in all plants; it varies according to the genera of the plants to which it belongs. Macquer follows Boerhaave in thinking, that it is generally a compound of an inflammable substance with a saline matter; but observes, that it sometimes partakes more of a saline nature, and at other times approaches nearer in nature to oily matters. The aroma of cruciform plants, he thinks to be

saline;

ſaline; and aſcribes to it to the characteriſtics of being pungent and penetrating, yet not affecting the nerves: That, again, which is inſipid, or ſtrong, but not pungent, and affects the nerves, ſo as either to occaſion, or to mitigate, fits owing to the particular ſtate of the nervous ſyſtem,—effects which aromatic and narcotic plants uſually produce;—that, according to this celebrated chemiſt, has more of an oily than of a ſaline nature. Several facts concur to ſupport this opinion. The fraxinella diffuſes an odour which forms an inflammable atmoſphere around it; and whenever a burning body comes within this atmoſphere, it takes fire; and the vapour then burns from the lower to the upper part of the ſtem that ſupports the flowers.

The aroma of the fraxinella ſeems therefore to be of an oily nature. Venel, a chemiſt at Montpelier, who ſtudied under Rouelle, extracted an acid ſpiritus rector from ſavoy (marum) by a gentle heat; and Roux, profeſſor of chemiſtry in the ſchools of medicine, having examined the product, found that it did not redden vegetable colours, but ſaturated alkalis. With reſpect to the aroma of cruciform plants, chemiſts are not yet agreed concerning its nature. Some think it acid; others call it alkaline. It appears from the experiments of Meſſrs Deyeux and Baumé, that ſulphur is found in combination with the odorate principle of antiſcorbutic plants; and that it is this combuſtible body, reduced to the ſtate of elaſtic fluidity, by combination with hydrogene, which conſtitutes the aroma of cruciform plants.

There are yet two important obſervations to be made concerning the aroma of plants. In the firſt place, it is perhaps, as Macquer ſuſpected, a gas of a peculiar nature:

ture: its invisibility, its volatility, the manner in which it diffuses itself through the atmosphere, its power of expansion, together with some experiments by Dr Ingenhousz on the noxious gas exhaled from flowers, render this opinion highly probable.—What we want to determine this point, is a series of experiments, which would indeed require to be performed with the utmost care and accuracy, but would certainly accomplish some noble and useful discoveries. Boyle has already opened a wide field of inquiry concerning smells, their alterability and reciprocal combination: and that train of research has been very successfully prosecuted by Lorry. This philosopher has observed the alterations produced on them by mixture with one another, by fermentation, and by the action of fire, air, and different menstrua.—We cannot, without making an improper digression, enter here into a particular detail of his experiments; but we may mention his general division of smells. Lorry divides these bodies into five classes, camphorate, æthereal, poisonous, or narcotic, acid, and alkaline: All smells may, in his opinion, be referred to some one of these classes. In explaining the grounds on which he establishes this division, founded on the manner in which smells affect the sense of smelling, and the nerves in general, Lorry informs us, that he proposes not to examine their chemical nature: But it is probable, as he himself thinks, that those of each class are nearly of the same nature in respect to chemical properties, as well as to the manner in which they affect the animal œconomy.

Our second observation, and with it we mean to conclude the chemical history of the principle of smell, is, that though the plants which have been called inodorous,

rous, be thought to contain none of this principle; yet is it at present a well known fact, that, by the gentlest heat of a balneum-mariæ, there may be extracted from them a water, of which the smell, though very faint, will however be sufficient to indicate from what plant it was extracted.—I can assert this upon my own experience. I have often found those plants that are commonly reckoned the most inodorous, such as succory, plantain, borage, &c. to afford, by the balneum-mariæ, a water that diffuses a smell, by which the nature of the plant from which it was extracted may be sufficiently known. It is true, that these insipid aromatic waters are very soon decomposed, and lose, in a short time, that faint smell by which they are distinguished: They are altered, and ferment, and pass either into an acid or an alkaline state.

The perfumer's art is founded on the method of extracting the odorous parts of vegetables, of preserving, and of fixing them in different substances. Most of the processes of that art are entirely chemical.

Medicine, too, makes much use of distilled or aromatic waters. They possess different virtues, according to the peculiar nature of each. Those employed for the purposes of medicine are usually distilled by naked fire, with water, in the same way as volatile oils. This manipulation answers very well for the aroma of such waters as are truly aromatic, but not so well with those plants that are commonly called inodorous. These ought to be distilled in a balneum-mariæ; and as this precaution is seldom taken, they have usually an empyreumatic smell, acquired from the fire, even when not impregnated with the odorous principle of the plant.—If these waters owe all their virtue to the aroma which they contain, weak as

that

that is, it is certain that the mode of preparing them destroys all the properties which that principle can possibly confer upon them.

To these observations we shall only add, that the distilled waters of plants prepared by the apothecary, are not that pure aroma which Boerhaave called *spiritus rector*, but that principle, diluted in a large proportion of water, distilled with the plants.

CHAP.

CHAP. XIII.

Of Resinous Inflammable Juices in general, and of Balsams in particular.

THE name *Resins* is given to certain dry inflammable matters, which cannot be mixed with water, but are soluble in oils and alcohol, and run fluid from the trees in which they are produced. These matters are nothing but oils concreted by the deficcative action of the air. Various opinions are entertained concerning the difference between balsams and resins. Some give the name of balsams to inflammable fluid substances; but there are also dry balsams: Others confine the name to the most odorous inflammable substances. Bucquet has thrown much new light on this matter, by confining the name of *balsams* to such of those combustible matters as are sweet-smelling, and can communicate their smell to water: and especially, which contain odorate and concrete acid

salts,

alts, that may be obtained from them by sublimation, or decoction in water.

The principal species of balsams are the three following:

1. Benzoin. Of this there are two sorts: the amygdaline benzoin, in white tears resembling almonds, united by a brown juice; and common benzoin, of a brown colour, not in tears: it exhales a very pleasing smell, when melted or pricked with a hot needle. The tree that affords it is but little known. Linnæus, the son, calls it terminalia benzoin. Murray observes, that the wood and the bark of this tree diffuse an odour of benzoin whilst burning. The same author thinks it doubtful, however, whether it affords this balsam or not. This balsam comes to us from the kingdom of Siam, and the island of Sumatra. On account of its solidity, it affords but little essential oil. Boiling water extracts from it an acid salt in needles, which is strong smelling, and crystallizes by cooling. The salt is also obtained by sublimation. When obtained by this last process, it is called *flowers of benzoin*. This operation is performed in two varnished earthen pots, placed one above the other, and made close with paper at the place of their junction. The fire must be moderate, otherwise the salt becomes brown. The pasteboard cone which was formerly used for this purpose suffered a great deal of the concrete acid to escape. We have given an account of the properties of this acid in a preceding chapter. Benzoin affords, in a retort, a very acid phlegm, a concrete brown salt of the same nature,

 and

and brown thick oil: the residual coal contains fixed alkali.

Benzoin is soluble in alcohol; and the tincture of this balsamic substance, precipitated by water, forms *lac virginale*. Salt of benzoin is used as a good incisive in pituitous disorders of the lungs and reins. The oil is discussive, and is externally applied to limbs affected with palsy, &c.

2. Balsam of Tolu, Peru, and Carthagena. This balsam is brought to Europe, either in cocoa-nut-shells, or in yellowish tears, or in a fluid state: it flows from the toluifera, which Linnæus ranks in the decandria monogynia class. It may be extracted from the shells by steeping them in boiling water, which renders it fluid. It comes from a country in South America, situated between Carthagena and Nombre de Dios, called by the inhabitants of the islands Tolu, and by the Spaniards Honduras. It affords, when analysed, the same products as benzoin, and especially a concrete acid salt. It is made into syrup, and administered in diseases of the lungs.

The acid of the balsam of Tolu has not been yet examined: it is thought not to differ essentially from the benzoic acid.

3. Storax calamita is in tears, either red and clean, or brown and greasy. It smells very strong; it runs from the oriental liquid ambar, a plant that is but little known. Duhamel observed a juice running from the *aliboufier*, that had nearly the same smell. Neumann analysed the storax calamita, and obtained from it an essential oil, a concrete acid salt, and a thick oil. It serves for nearly the same purposes as benzoin;

benzoin: it is chiefly used for perfume. We formerly had it sent to us in reeds; but we now get it in loaves, or irregular masses, of a reddish brown colour, mixed with a few tears of a lighter colour, and a more pleasant smell.

CHAP. XIV.

Of Resins.

RESINS differ from balsams, as having a less pleasing smell; and, still more eminently, as containing no concrete acid salt. The following are the principal species of resins.

1. Balsam of Mecca, Judæa, Egypt, Grand Cairo. It is liquid, white, bitter, and of an high lemon-colour. It runs from a tree that is called *amyris opobalsamum*, ranked by Linnæus in the octandria monogynia, and discovered in Arabia the Happy by M. Forskahl. This liquid resin affords a great deal of essential oil by distillation. With sugar, and yolks of eggs, &c. it is used as a vulnerary.

2. Brown or yellow balsam of Copahu, which runs from the tree called *copaiba*, and by Linnæus *copaifera*, and ranked by that botanist in the decandria monogynia. The common kind, both of this and of the balsam of Tolu, is, according to Cartheuser, a mixture of genuine

genuine balsam of Copahu with turpentine. It is used, as well as the preceding resin, as a remedy for ulcers of the lungs and bladder.

3. Chio turpentine runs from the turpentine-tree that bears the pistachio-nuts. It is of a white or yellow colour, inclining to blue. It affords, on a balneum-mariæ, a very fluid volatile oil: that which it affords by naked fire is not so fluid. The turpentine is, after this operation, of a still yellower colour. When distilled with water, it is white and silky, and is called *boiled turpentine*. This turpentine is not common, and is not applied to any use.

4. Venetian turpentine, or Milesian resin, is that most commonly used in medicine. It is used either in its natural state, or combined with fixed alkali. This composition has been called *Starkey soap*. We consider it as a *saponula*. To prepare it, the Paris Dispensary directs to pour four ounces of volatile oil of turpentine on half a pound of nitre fixed by tartar, and still hot; to stir the mixture with an ivory spatula, and cover the vessel with a piece of paper; adding oil, by degrees, till the whole form one white mass. This process takes up several months; and chemists have therefore sought to find out some more expeditious method of making up the medicine. Rouelle prepared, in the space of three hours, a pretty considerable quantity of this soap, by triturating alkali with the oil dropped upon it, and adding a little water towards the end of the operation. M. Baumé directs to levigate upon porphyry one part of alkali of tartar, previously exposed to heat till it shall have been brought near the point of fusion; and to add to it, by

degrees, two or three times its weight of volatile oil. When the mixture is brought to the consistency of a soft opiate, put it into a glass-cucurbite, covered with paper, and set it aside in a damp place. In fifteen days time, the deliquescent alkali forms a distinct portion of liquor at the bottom of the vessel; the soap occupies the middle; and a portion of the oil, having assumed a red colour, swims on the surface. M. Baumé thinks that the alkali unites only with that portion of the oil which is in a resinous state. M. le Gendre pursues this idea farther, and proposes to saturate a cold solution of the fixed alkali with concentrated oil of turpentine, or even with turpentine itself. This soap is in some degree solid, and becomes gradually more so: crystals are formed in it, which have been considered as a combination of the acid of the oil with vegetable fixed alkali. But, according to the academicians of Dijon, they are nothing but potash saturated with carbonic acid, and crystallized in that state. As it is no easy matter to make up this soap, and it is, besides, very liable to alteration, Macquer thinks, that when a substance is wanted, possessing the properties of volatile oils, and those of soaps, in union, it were better on any occasion to incorporate a few drops of volatile oil with medicinal white soap, to serve the present purpose. Ammoniac, triturated with turpentine, forms a solid saponaceous compound, which dissolves very readily with water, and renders it milky and frothy.

5. The resin of the fir-tree is called turpentine of Strasburg. It is obtained by piercing the vesiculæ of

the bark of the fir-tree, of which there are extenſive foreſts on the hills of Switzerland.

6. Pitch is the juice of a ſort of a fir-tree, called *abies picea*. It is obtained, by inciſion, from the bark of the tree. It is melted by a moderate fire, preſſed in bags of cloth, and received into barrels: This is Burgundy pitch, or white pitch; by mixture with lamp-black, it is converted into black pitch. When it is kept long in fuſion with vinegar, it becomes dry and brown, and ſo forms what is called *Colophony*. The more impure parts are burnt in a furnace, with a chimney paſſing into a ſmall cabinet, terminating in a cone of cloth: the ſmoke is condenſed in this cone, into a fine ſoot, that is called *lamp-black*.

7. The galipot is the reſin of the pine which bears the ſoft apples. This tree is notched towards the bottom, and the reſin runs out into troughs. When the reſin ceaſes to run out by the lower holes, they are continued upon the tree. When it runs fluid, it is called *galipot;* that which hardens upon the tree into yellowiſh maſſes, is called *Barras*. Theſe juices are liquified in boilers; and after being concentrated by heat, are filtrated through ſtraw-mats, and run into moulds in ſand, or formed into loaves that are called *arcançon*, or *bray-ſec*. When water is poured in, the matter becomes white, and forms *reſin*, or *pitch-reſin*. The inhabitants of Provence diſtil galipot: they extract from it an oil which they call *huile de raze*. *Tar*, which is the empyreumatic oil of this ſubſtance, is prepared from the trunk and roots of the pine. A quantity of the wood is heaped together, covered with

turf, and set on fire. The turf hinders the oil that is disengaged by the heat from being volatilized; and it passes into a shallow tub through a channel, out of which it is removed, without farther preparation, to be sold as *tar*.

8. Tacamahaca, gum elemi, gum animæ, are very little used. The tree that affords the first is unknown. The *elemi* is produced by a species of *amyris*. The oriental gum animæ, or copal, the origin of which is unknown, and the occidental gum animæ, or courbaril, which flows from the *hymenæa*, a tree that grows in South America, are used for varnishes.

9. Mastic is in white, farinaceous tears, of a faint smell: It flows from the turpentine tree, and the mastic tree; it is used as an astringent, and an aromatic; it enters into the composition of drying varnishes.

10. Sandarac is in white tears, more transparent than those of mastic. It is obtained from the juniper-tree, in which it occupies a place between the bark and the wood. It is likewise called *varnish*, as it enters into those preparations. It is used, in powder, to prevent ink from sinking on paper, from which the external coating of size has been scraped off.

11. The resin of guayacum, which is greenish, is used as a remedy for the gout. It is obtained, by incision, from the guayacum tree.

12. Labdanum the resin of a species of cistus in Candia, is of a blackish colour. The peasants gather it by striking the trees with staves, having a number of leather-thongs fixed to the one end. They make it up into cylindrical pieces, which they call *ladanum in tortis*.

It is adulterated by a copious addition of blackish sand: It is used as an astringent.

13. Dragon's blood is a red juice, extracted from the *dracæna draco*, and some other trees of a similar nature. It comes to us in small flat cakes, or round balls, or in little spherical pieces, wrapped up in leaves, and knotted like a chaplet. It is used in medicine as an astringent.

CHAP. XV.

Of Gum Resins.

GUM RESINS are mixed juices, consisting of resin and extractive matter, which has been taken for a gummy substance. They run by incision, but never naturally, from trees or plants, in the form of white, yellow, or red emulsive fluids, which are sooner or later consolidated. Water, alcohol, wine, vinegar—none of all these liquors dissolves more than a part of gum resins. They differ in the proportions of the resin and the extract, and afford, by analysis, many various results. The following are the most important species:

1. Olibanum consists of yellow transparent tears, of a very strong and disagreeable smell. It is not known from what tree it flows. It affords, by distillation, a small portion of volatile oil, and an acid spirit, leaving a pretty large residual coal, produced from the extractive matter which it contains. It is used in fumigations as a resolvent medicine.

2. Galbanum is a fat juice, of a brown-yellow colour, and

and a nauseous smell. It runs, in Arabia, Syria, and at the Cape of Good Hope, from incisions in a ferulaceous plant, called *Bubon Galbanum* by Linnæus. When distilled by naked fire, it affords a blue essential oil, which afterwards becomes red, an acid spirit, and a ponderous empyreumatic oil. It is an excellent discussive, and a powerful antispasmodic.

3. Scammony is of a blackish grey colour, a strong nauseous smell, and a bitter and very acrid taste. The scammony of Aleppo is by far the purest. That of Smyrna is ponderous, black, and mixed with extraneous bodies. It is extracted from the *convolvulus scammonia* of Linnæus. The root of the plant, cut and squeezed, affords a white juice, which, when dried, becomes black. The various specimens of scammony contain various proportions of extract and resin; on which account its effects as a medicine are far from uniform. It is given as a purgative, in dozes of from four to twelve grains. Mixed with a sweet extract, such as that of liquorice, it forms the common *diagredium*. It is likewise used for this purpose with the juice of quinces. It is usually given in a powder with sugar and sweet almonds.

4. Gum guttæ is yellow, reddish, destitute of smell, and of a strong, acrid, and corrosive taste. It comes from Siam, China, and the island of Ceylon. It is extracted from a large tree, very little known to us, and distinguished in the countries where it grows by the name of *Coddam Pulli*. It contains a good deal of resin, which renders it strongly purgative, when administered in dozes of four or six grains. It should be very cautiously administered internally.

5.

5. Euphorbium is ~~in~~ yellow tears, which are of a carious or worm-eaten appearance, and have no ſmell. It runs from inciſions in the plant *euphorbium*, which grows in Ethiopia, Lybia, and Mauritania. It contains a very acrid reſin. It is ſo ſtrongly purgative, as to be ranked among poiſons. The only medical uſe for which it ſerves, is in external applications to caries.

6. Aſſa-fœtida is ſometimes in yellowiſh tears, but ofteneſt in loaves, conſiſting of different pieces agglutinated together. It has a very fœtid ſmell of garlic, and taſtes bitter, and nauſeouſly diſagreeable. It is extracted from the root of a ſort of *ferula* that grows in the province of Chorazan in Perſia, and has been called by Linnæus *Aſſa-fœtida*. The root of this plant is fleſhy and ſucculent. It affords, by expreſſion, a white juice, of an abominable ſmell, uſed by the Indians as a ſeaſoning, and called by them *food for the Gods*. It is uſed internally as a powerful antiſpaſmodic, and externally as a diſcuſſive.

7. Aloes is a juice of a dark red, and ſometimes even a brown colour, with conſiderable bitterneſs of taſte. There are three kinds of it: ſocotorine aloes, hepatic aloes, and caballine aloes. The firſt is the pureſt; and it is only in purity the three ſorts differ. A. de Juſſieu ſaw theſe ſeveral kinds of aloes prepared at Morviedro, in Spain, from the leaves of the common aloes. Deep inciſions were made in the leaf; the juice ran out by theſe: It was then decanted from above the fæcula, and thickened by expoſure to the ſun. The aloes prepared in this manner is put up in leather-bags, and ſold under the name of ſocotorine aloes. The juice ſqueezed from the leaves, purified by reſt, and then dried, forms hepatic

hepatic aloes. Lastly, The leaves are again pressed; and the juice now obtained from them, mixed with the lees remaining from the two former operations, forms caballine aloes. The first of these different sorts of aloes contains much less resinous matter than either of the two latter, and is therefore much less purgative. It is used in medicine as a drastic purge, and is known to possess the property of bringing on the menstrual flux with women, and the hæmorrhoidal flux with men. It is recommended as an excellent hydragogue.

8. Myrrh is in the form of reddish tears, of a brilliant appearance, of a pretty strong but agreeable smell, of a bitter taste, and exhibiting in their fracture, when broken, white lines of the form of a nail. Some of these tears are entirely gummy and insipid. Myrrh comes from Egypt, but chiefly from the ancient country of the Troglodytes, in Arabia. The plant that affords it is unknown to us. It contains much more extract than resin. It is used in medicine as a very good stomachic, an antispasmodic, and a cordial. Cartheuser advises literary people, who have delicate stomachs, to chew and swallow it with their spittle. It is used in surgery for cleansing putrid ulcers, and stopping the progress of caries, either in powder, or diluted in spirit of wine.

9. Gum ammoniac sometimes appears in tears that are white internally, but externally yellow, and often in masses much like those of benzoin. They are easily distinguished, however, by their white colour and fœtid smell. This gum resin, which we get from Africa, is thought, on account of the seed mixed with it, to be extracted from an umbiliferous plant. This substance being soluble in water and spirit of wine, as well as inflammable,

is nearly of the ſame character with thoſe which Rouelle has named reſinous extractive matters.

In medicine, gum ammoniac is uſed as a very good diſcuſſive in caſes of obſtinate obſtruction. It is given in doſes of a few grains, either in pills or emulſions: it enters alſo into the compoſition of many diſcuſſive and reſolvent plaſters.

10. Elaſtic reſin, or caout-chouc, is a ſubſtance concerning the nature of which it is hard to ſay any thing. Its containing combuſtible matter, which is uſed in America for lights, is a characteriſtic in which it agrees with reſinous ſubſtances: but its elaſticity, ſoftneſs, and inſolubility in the menſtrua, which uſually diſſolve reſins, diſtinguiſh it as a ſubſtance of a different nature.

The tree which affords it, grows in various parts in America. Large inciſions are made through its bark, which muſt always penetrate to the wood: a white juice, more or leſs fluid, flows from it, and is received into veſſels, in order that it may be applied to the different purpoſes for which it is ſuitable: it is laid in layers on clay moulds; and dried by expoſure to the ſun, or to fire. Various deſigns are then ſketched upon them with the point of an iron inſtrument: they are then expoſed to ſmoke; and when ſufficiently dried, the moulds are broken. In this way are formed the bottles, and other utenſils of elaſtic gum, that come into Europe.

The veſſels made of this matter are capable of holding water, and ſuch other fluids as have no power of acting upon it. If it be cut into pieces, and the edges applied to each other ſoon after they are cut, the pieces unite again. I examined juice of caout-chouc, which was ſent me from Madagaſcar. It was white as milk, and its ſmell inſuf-

ferably fœtid. It contained a concrete, white, ſpongy matter, in the middle of the bottle, of a ſimilar form, and likewiſe elaſtic. When the liquor was heated, a white pellicle of genuine elaſtic reſin was very ſoon formed on its ſurface. Alcohol, mixed with the juice, ſeparated from it flakes of that reſin.

When the caout-chouc, in a dry ſtate, ſuch as it is ſent into Europe, is expoſed to fire, it becomes ſoft, ſwells, exhales a fœtid odour, and ſhrinks as it burns.

Elaſtic reſin is not ſoluble in water. We know not in what manner ſaline matters act upon this ſubſtance. Macquer, after trying to diſſolve it in various menſtrua, was convinced of what had been before aſſerted by Meſſrs de la Condamine and Freſneau, (*Academy, year* 1751), that alcohol was incapable of acting upon it, but that oils diſſolved it with the help of heat. However, as he wiſhed to reduce it to a liquid ſtate, ſo that it might be made uſe of in that form, and might recover its properties by the evaporation of the ſolvent liquor, he was obliged to employ another menſtruum than oils; becauſe oils, however volatile, always altered the elaſtic reſin, and became fixed in it, ſo as to weaken its ſtrength, and deſtroy its elaſticity. He at length diſſolved this ſubſtance in highly rectified æther; and this being ſo very ſubject to evaporation, perfectly ſuited his purpoſe: (*Academy, year* 1768). And though that liquor be indeed very dear, yet he thought it might be of ſome conſequence to make known to the public a method of making ſome very uſeful inſtruments, ſuch as catheters, by putting, on a waxen mould, ſucceſſive layers of this ſolution, till they be of the required thickneſs. When the catheter is dry, let it be immerſed in boiling water,

which, by melting the wax, separates it from the mould. The softness and elasticity of a catheter of this substance, render it the most proper for persons who find it necessary to wear such an instrument constantly.

These are all the particulars of the history of elastic gum that were known to the world before the month of April 1781; at which time M. Berniard, distinguished by the accuracy of his experiments, inserted in the *Journal de Phisique* an excellent Memoir on this singular substance. That chemist concludes from his experiments, that elastic resin is a peculiar fat oil, coloured by a matter soluble in alcohol, and contaminated with the soot of the smoke to which each layer of the resin must be exposed, in order to dry it. Water produces no alteration upon it: alcohol, assisted by a boiling heat, discolours it. Caustic fixed alkali is incapable of acting upon it. The concentrated sulphuric acid reduces it to a carbonaceous state, and is itself at the same time tinged with a black colour, and takes the smell and the volatility of the sulphureous acid. The common or weak nitric acid acts on this resin in the same way as on cork, and gives it a yellow colour; the nitric acid, strongly concentrated, decomposes it very rapidly; the muriatic acid produces no sort of alteration upon it; rectified sulphuric æther did not dissolve it: This fact must appear singular, as the author observes, to all those who know the accuracy and veracity of Macquer. Nitric æther did dissolve it. This solution was yellow, and afforded, by evaporation, a transparent substance, friable, and soluble in alcohol;—in a word, a genuine resin, formed, according to this author, by the action of the nitric acid on the elastic caout-chouc. The volatile oils of

of lavender, aspic, and turpentine, dissolved it with the help of a gentle heat; but they formed clammy fluids, which stuck to the hands, and could not therefore be applied to any useful purpose. A solution of elastic resin by oil of aspic, when mixed with alcohol, deposited white flakes, which were insoluble in hot water, but floated on the surface of that fluid, and became, by cooling, white and solid like wax; in a word, they formed a genuine, fixed, concrescible oil. Oil of camphor dissolved elastic resin by simple maceration. When the solution was evaporated, the camphor was volatilized; and there remained in the capsule an amber-coloured matter, of a firm consistency, but scarce gluey, and easily soluble in alcohol. Fixed oils, when boiled upon elastic resin, dissolve it: wax likewise dissolves it. This substance does not melt by a boiling heat; but when exposed to the action of fire in a silver spoon, it is reduced into a thick black oil: It then exhales white vapours; after which it remains fat and clammy, though exposed to the air for several months; nor does it ever again recover its dryness and elasticity, which are so necessary to fit it for the purposes to which it is applied. Lastly, M. Berniard concluded his experiments on this substance, by analysing it by naked fire. From an ounce of elastic gum he obtained a very little phlegm; an oil which, though at first clear and light, became afterwards thick and coloured; and ammoniac, the quantity of which he does not specify: There remained a coal, similar to those of other resinous substances, which weighed twelve grains. This chemist ascribes the origin of the ammoniac to the soot which colours gum elastic.

On this analysis we may observe, that it does not determine, in a very accurate manner, the nature of elastic resin: for acids act not on this substance in the same way as on fat oils; they act on these bodies with much more rapidity than on elastic gum; neither do caustic alkalis reduce it to a saponaceous state: nor does it melt, unless a much stronger heat be applied to it than is sufficient to reduce the most solid fixed oils to a state of fluidity: and, besides, no fixed oil ever becomes dry and elastic, like elastic resin, &c. &c. In his fifth experiment, too, the author asserts this gum to consist of two distinct substances, the nature of which he does not explain; and concludes with representing it as a product of human industry. From these reflections, and many others which might be added, concerning these experiments of M. Berniard's, which are in other respects very well performed, we are induced to think, that much still remains to be done, as he himself acknowledges, before we can be fully acquainted with the properties of this substance, or can decide with certainty concerning its nature.

CHAP. XVI.

Of the Pure Fæcula of Vegetables.

THE juices of vegetables, when elaborated in their vessels, become thick, and are by degrees deposited on the surfaces of their fibres, where they contribute to their increase and nourishment, or are accumulated in a more or less solid form, in the different organs of which the vegetable consists. After speaking of the fluid parts of these organic substances, we come next to examine the substance of which the contexture of their solids is formed.—We are as yet far from being sufficiently acquainted with the nature of all those solid matters which compose the organs of plants. However, those particulars which are known to us, on this head, shew that those organs, when treated by processes which we are going to describe, are reducible to a dry, pulverulent, insipid substance, either white, grey, or variegated with different colours, insoluble in cold water, and seemingly earthy, which is called *fæculum*.

To obtain this ſubſtance, the root, ſtem, leaves, or ſeed of a plant, is pounded down to a pulp with a peſtle. When theſe parts are ſucculent, there is no occaſion for adding water to aſſiſt the proceſs; but this fluid is uſually employed to facilitate the ſeparation of the fibres, and to take up the attenuated pulverulent parts. When reduced by this proceſs to pulp, the vegetable ſubſtance is then ſqueezed; the juice or water obtained from it by preſſure is either turbid, white, or coloured; and it gradually depoſites, by reſt, a flaky matter, partly fibrous, and ſometimes pulverulent, which is the true fæculum of the plant. Some parts of vegetables appear to conſiſt entirely of this matter; ſuch as the ſeeds of gramineous and leguminous plants, tuberculous roots, &c. Theſe parts uſually afford the fineſt fæculum, and the greateſt quantity of that matter. As to the tender ſtems and leaves, their texture, being more fibrous, never affords, when treated by this proceſs, any thing but a coarſe, coloured, filamentous ſubſtance, which is known by the name of *coarſe fæculum*. If, after being thoroughly dried, theſe be reduced to powder, and the powder lixiviated, the water takes up a much finer fæculum, preciſely of the ſame nature with that of tuberculous roots and gramineous ſeeds. In the eye of the chemiſt, therefore, there is no other difference between theſe two kinds of fæcula, but that the firſt is produced from a part which is leſs fibrous, not ſo perfectly organized, and apparently formed of ſmall cells, in which Nature has depoſited a dry or farinaceous mucilage; whereas the ſecond, being wrought into a tiſſue of fibres, needs to have its organization deſtroyed, and to be attenuated by art.

Strictly

Strictly ſpeaking, all the ſolid parts of vegetables are apable of affording a ſort of fæculum. But that which prepared for the arts, for pharmacy, and for aliients, muſt here be more immediately the object of our ttention. The fæcula of briony, potatoe, caſſava, ſago, dop, ſtarch, are thoſe which deſerve to be particularly iken notice of, as applied to theſe purpoſes.

1. To prepare the fæcula of briony, take the freſh ots of the plant, ſtrip off the bark, raſp the root pieces, and then ſubmit them to the preſs. The juice jueezed out by the force of the preſs is white, and deoſites a very fine fæculum. At the end of four and venty hours, decant off the juice; dry the fæcula. As ie juice muſt have left in it a certain quantity of exact, it is very acrid, and purges violently. If waſhed efore being dried, it becomes finer and whiter, but loſes the ſame time its purgative powers. But this way of reparing the fæcula of briony affords only a very ſmall uantity. Much more may be obtained by diluting in ater the maſs which remains in the preſs, paſſing that ater through a hair-ſieve, and ſuffering it to ſtand unſturbed, till it depoſite the fæcula which it contains. Vhen this is depoſited, let the water be decanted off, id the ſediment dried. This fæculum, obtained by aſhing the lees, is not of a purgative nature, like the rmer, as the water has carried off the extractive mat- r in which that virtue reſided. M. Baumé has obſerved, iat the fæculum of briony, when well waſhed, bears an act reſemblance to ſtarch, and that hair-powder might e made of it; by which means, the wheat made uſe of r that article would be ſpared for other purpoſes. The

fæcula of the roots of calves-foot and corn-flag are prepared in the ſame way for medical uſe.

3. Potatoes, being ſo plenteous, and affording in a crop ſuch large increaſe, form one of the moſt uſeful articles of food. We can very eaſily extract from them a great deal of very fine white fæculum, that becomes, by roaſting, boiling in water, &c. a nouriſhing article of food. This fæculum may be obtained by grating down the potatoes on a ſieve, and pouring plenty of water upon them. The fluid carries off the fineſt and moſt attenuated portion of the fæcula, and, after ſtanding for ſome time undiſturbed, depoſites it. Decant off the water; dry the fæculum by a gentle heat: it is now in the ſtate of a very fine light white powder. For the preparation of large quantities of this powder, mills, or a ſort of graters turning on cylinders, have been contrived, which appear to be very happily adapted to the purpoſe.

3. The Americans extract, from the root of a very acrid plant called *manioc*, a very pleaſant nouriſhing fæculum, to which they give the name of Caſſava. In preparing it, they ſtrip the root of its bark, grate it down, and put it into a ruſh-bag, of a conical figure, and a very ſlight looſe texture, and hang the bag upon a ſtick, reſting horizontally on two wooden forks. To the lower end of this bag they fix a very heavy veſſel, which, by its weight, ſqueezes out the juice, and, at the ſame time, receives it as it runs. The juice is a very acrid and noxious poiſon. When the fæcula are ſufficiently preſſed, and all the juice drawn off, it is then dried by expoſure to ſmoke, and paſſed through a ſieve; and now it is in a proper ſtate for being baked into caſſava.

It

It is now ſpread on a plate of hot iron, and turned till it be ſo completely roaſted, as to take on both ſides a reddiſh yellow colour. In this ſtate it is called Caſſava bread. When expoſed to heat in a baſon, and ſtirred from time to time, it takes, as it dries, a granulated form; in which ſtate it is called *couac*. From the juice that was ſqueezed from the fæcula, there is by degrees a very fine ſweet-taſted fæculum precipitated, which is called *mouſſache*, and uſed in paſtry.

4. Sago is a dry fæculum, reduced to grains, and a little reddened by the action of fire, which we get from Java, and from the Molucca and Philippine iſlands.—It is extracted from a ſort of palm-tree, called in the Moluccas *landan*. The trunk of that tree incloſes a ſweet marrow, which the inhabitants extract by ſplitting the tree longitudinally. They then ſcrape down this marrow; put it into a ſort of cone or funnel made of the bark of a tree, place the cone upon an hair-ſieve, and pour upon it a good deal of water.—The fluid conveys with it, through the holes of the ſieve, the fineſt and whiteſt part of the marrow, leaving the fibrous part ſtill upon the ſieve.—The water impregnated with the attenuated part of the marrow is received into pots, in which the fæculum is ſoon depoſited, and it becomes tranſparent.—The water is now decanted off, and the ſediment paſſed through ſmall plates perforated with holes, which give it the granulated form by which ſago is uſually diſtinguiſhed.—The reddiſh colour of the ſurfaces of the grains is owing to the action of the fire by which they are dried.—Theſe grains become ſoft and tranſparent in boiling water. With milk or broth, they make a

 ſort

ſort of ſoup, which is light, and pleaſant to the taſte, and is greatly recommended in phthiſical caſes.

5. Salep, ſalop, ſalab, &c. is a ſubſtance which the inhabitants of the Eaſt prepare from a ſpecies of *orchis*. They ſelect the fineſt bulbs of that plant, firſt peel them, and then ſteep them in cold, and boil them in hot water; next, after the water is well drained from them, they are ſtrung in bunches, and dried in the air. M. Jean Moult gives another proceſs for the preparation of ſalep, by which it may be prepared from any ſpecies of orchis.—The roots muſt be rubbed, either dry or in water, with a bruſh, to remove the exterior pellicle, and then dried in an oven. They then become very hard and tranſparent. But they may be very eaſily reduced to a powder; and this powder, diluted in hot water, forms a nouriſhing jelly, the virtues of which Geoffroy mentions with very laviſh praiſe, as highly efficacious againſt all diſeaſes occaſioned by an acridity of the lymph, more eſpecially againſt conſumptions and the bilious dyſentery.

CHAP.

CHAP. XVII.

Of the Farina of Wheat, and of Starch.

STARCH, properly ſo called, is a fæculum preciſely of the ſame nature with thoſe of which we have already given an account: But as the farina of wheat, of which ſtarch is a conſtituent part, is one of the moſt important matters that can engage the attention of the chemiſt, we ſhall deſcend to a much more particular account of this than we have given of any of the other fæcula.

What is called farina, is in general a dry, friable, inſipid ſubſtance, capable of acquiring ſapidity and ſolubility by the action of fire, and conſiſting of ſeveral matters, which may be very eaſily ſeparated from one another. This ſubſtance is diſpoſed by Nature in the ſeeds of gramineous plants, eſpecially in thoſe of wheat, rye, barley, oats, rice, &c. Even leguminous plants appear to contain a compound of an analagous nature. There is, however, no other ſubſtance but the farina of wheat, which poſſeſſes all the ſame properties: none

but this farina poſſeſſes that juſt proportion of the conſtituent principles to which alone all its diſtinguiſhing properties can belong. Although the farina or flour of wheat has, from time immemorial, been uſed as a principal article of food, yet it has only within this ſhort time begun to be chemically examined. Meſſrs Beccari, an Italian phyſician, and Keſſel Meyer in Germany, are the firſt chemiſts who attempted to ſeparate the different matters of which farina conſiſts. Meſſrs Rouelle, Spielman, Malouin, Parmentier, Poulletier de la Salle, and Macquer, have proſecuted theſe reſearches a great way farther than the above-mentioned naturaliſts. M. Parmentier eſpecially has proſecuted them with very uncommon zeal and induſtry. His reſearches into the nature of theſe alimentary ſubſtances, the principles of farina, the different kinds of fæcula, and concerning nutritious vegetables in general, are undeniably the moſt complete and accurate of any thing that we have of the kind.

Water is of all agents the moſt uſeful, as it produces the leaſt alteration on the various matters with which it becomes impregnated, or which it ſeparates, according to the laws of their ſolubility. Accordingly, it is by this fluid that the different matters of which the farina of wheat conſiſts are moſt ſucceſsfully obtained ſeparate from one another. In performing this true analyſis, a paſte is firſt to be compoſed of the farina with water; the paſte muſt then be kneaded in an earthen veſſel, with water pouring upon it from a cock; the fluid, as it falls upon the paſte, takes up from it a very fine white powder, by means of which it acquires the colour and conſiſtency of milk: let this proceſs be continued

continued till the water run off clear. The farina is now found to be naturally ſeparated into three diſtinct ſubſtances—a grey elaſtic matter that ſticks to the hand, and on account of its properties has gained the name of the glutinous, or *vegeto-animal* part,—a white powder which falls to the bottom of the water, and is the fæculum or ſtarch,—and a matter which remains diſſolved in the water, and ſeems to be a ſort of mucilaginous extract. Let us proceed to an examination of the properties of each of theſe three ſubſtances.

§ I. *Of the Glutinous Part of Wheat.*

THE glutinous part is a tenacious, ductile, elaſtic matter, of a whitiſh grey colour. It may be extended to twenty times its natural length; and it then ſeems to conſiſt of fibres or filaments, diſpoſed beſide one another in the ſame direction in which it has been drawn out. When the power by which it was extended ceaſes to act, it then returns with elaſtic force to its primary form. By drawing it out in different directions, it may be rendered ſo fine as to reſemble, in the poliſh of its ſurface, the texture of the membranes of animals. In this ſtate, it adheres with conſiderable force to dry bodies, and forms a very tenacious glue, which was uſed by ſome people for the purpoſe of re-uniting pieces of broken porcelain, long before chemiſts had found out the way of obtaining it in large quantities. M. Beccari obſerves, that in the beſt flour the proportion of the glutinous matter is from a fifth to a third part, or even more:—he remarks, too, that this proportion varies,

varies, according to the ſeaſon, and the nature of the corn.

The glutinous matter has an agreeable and ſomewhat mucous ſmell; its taſte is inſipid; it ſwells amazingly when expoſed to a ſtrength of heat ſufficient to dry it quickly. It dries very well by a moderate heat, or even in the dry air. It then becomes ſemi-tranſparent and hard, like a ſtrong glue, and, like that ſubſtance, breaks with noiſe, and with a ſmooth fracture. If, when in this ſtate, it be laid on a burning coal, or held over the flame of a taper, it exhibits all the characteriſtics of an animal matter; it crackles, ſwells, becomes liquid, is agitated, and burns in the ſame way as a feather, or a piece of horn, exhaling a ſtrong fœtid ſmell. When diſtilled in a retort, it affords, like animal matters, water impregnated with ammoniac, ammoniacal carbonate, and an empyreumatic oil: the carbonaceous reſidue is very difficult to incinerate, and is found to contain no fixed alkali.

The gluten, when expoſed freſh to a moiſt and hot air, is altered, and actually putrefied in the ſame manner as animal matters. If it ſtill retain a little ſtarch, then the ſtarch, paſſing into the ſtate of acid fermentation, retards and modifies the putrid fermentation of the gluten, and reduces it to a ſtate in which it is much like cheeſe. In this way Rouelle the younger prepared, from this gluten, a ſpecies of cheeſe, in taſte and ſmell much the ſame with Dutch cheeſe, and that of Gruyere.

Water does not at all diſſolve this glutinous matter. When boiled in that fluid, it becomes ſolid, and loſes its tenacity and elaſticity, but neither acquires a taſte, nor becomes ſoluble in the ſaliva. We may, however, obſerve,

obſerve, that to the water which was uſed in making the paſte the gluten owes its elaſticity and ſolidity. In the farina, this vegeto-animal matter, which is thus ſuſceptible of a ſolid elaſtic form, was in an incoherent and pulverulent ſtate; but when the water is poured upon the farina, and mixed with it, thoſe particles which are of a glutinous nature abſorb the fluid, and are by its means ſo cloſely united, as to form, in a ſhort time, that ſort of elaſtic ſolid which is known by the name of Gluten. Water, therefore, contributes greatly to the formation of this ſubſtance, which is perhaps to be conſidered as a peculiar compound ſaturated with water, and, for that reaſon, not capable of abſorbing any more. So true is this, that if it be deprived of its water by deſiccation, it loſes entirely its elaſtic and adheſive powers.

Moſt ſaline ſubſtances act either with more or leſs force on this gluten. Potaſh and ſoda, in a cauſtic and liquid ſtate, diſſolve it with the help of a boiling heat. The ſolution is turbid, and, on the addition of acids, depoſites gluten, which, however, is deſtitute of elaſticity.

The mineral acids diſſolve this gluten. The nitric acid diſſolves it with great activity; and M. Berthollet has obſerved, that this gluten, as well as animal ſubſtances, gives out azote gas, when expoſed to the action of the nitric acid. After the emiſſion of this elaſtic fluid, the ſolution affords a great deal of nitrous gas, and takes a yellow colour. By evaporation, it affords oxalic acid in cryſtals. The ſulphuric and the muriatic acids form, with this ſubſtance, brown or violet ſolutions. A ſort of oily matter is ſeparated from theſe ſolutions:

the gluten exifts in them, in a real ftate of decompofition. M. Poulletier, who has made many experiments on this matter, has difcovered, that from thefe combinations, diffolved in water or alcohol, and evaporated in the open air, there may be ammoniacal falts obtained.

From what we have related concerning this fubftance, it appears, that it is entirely different from all thofe which we have before taken notice of, as exifting in vegetables; and that in many of its diftinguifhing properties, it bears a great refemblance to the fibrous part of blood. It is to this gluten the farina of wheat owes its property of forming a tough pafte with water, and its readinefs to rife with leaven. It appears either not to exift, or to exift only in a very fmall proportion, in the farina of other vegetable fubftances, fuch as rye, barley, buckwheat, rice, &c. all of which form folid, opaque paftes, fcarcely ductile, and brittle, and which can fcarce be raifed when expofed to the fame temperature by which pafte of the farina of wheat is raifed. No other fubftance but flour of wheat, therefore, is poffeffed of all the qualities neceffary for making good bread.

M. Berthollet is of opinion, that this glutinous fubftance, like animal matters, contains phofphoric falts, which are the occafion of its coal being fo difficult to incinerate. Rouelle the younger has difcovered a glutinous fubftance, refembling that of the farina of wheat, in the green fæcula of plants, which afford, by analyfis, ammoniacal carbonate and empyreumatic oil, like the vegeto-animal matter of which we have been fpeaking.

§ II.

§ II. *Of the Starch of Wheat.*

STARCH, the amylaceous fæculum, is the moſt copious part of the farina. This is the ſubſtance which is carried off, and afterwards precipitated from the water with which the paſte is waſhed, in order to obtain the pure gluten. This ſubſtance is very fine, feels ſoft, and has no perceptible taſte. Its colour, when it is extracted by the proceſs above deſcribed, is a dirty grey-white; but the manufacturers of ſtarch render it exceedingly white, by ſteeping it in an acid water, which they call *ſour water*. It appears, from the experiments of M. Poulletier, that the fermentation which takes place in that fluid whitens and purifies the ſtarch, by attenuating, and even deſtroying, the extractive mucous ſubſtance which is precipitated with it in the firſt waſhing. Starch, chemically conſidered, is a mucilage of a peculiar nature. This mucilage, which by ſome chemiſts has been miſtaken for an earth, is very different from the gluten. It does not, like the gluten, diffuſe an empyreumatic ſmell when it burns. When diſtilled by naked fire, it affords an acid phlegm, of a brown colour, and, towards the concluſion of the proceſs, a very thick empyreumatic oil. The coaly reſidue is eaſily enough incinerated; and its aſhes are found to contain fixed alkali.

Starch is not ſoluble in cold water; but when boiled in water, it forms with the fluid a glue, or rather what in French is demoninated by the peculiar name of *empois*. This compound, when expoſed to damp air, loſes

by degrees its consistency, ferments, becomes sour, and is covered over with mouldiness.

The nitric acid affords, with this fæculum, oxalic acid, perfectly the same with that of which we have spoken in the foregoing chapter.

As starch forms the greatest part of flour, there can be no doubt of its being the principal alimentary substance contained both in flour and in bread.

§ III. *Of the Extractive Mucilaginous Part of the Farina.*

BY evaporating the clear water that had been used in washing the paste, and had deposited the starch, M. Poulletier obtained a viscous, adhesive matter, of a brown-yellow colour, the taste of which was faintly saccharine. This substance, to which he gave the name of *mucoso-saccharine*, displayed, in combustion and distillation, all the same phænomena with sugar. By it the acid fermentation is produced in the water which swims over starch; for, as Macquer has observed, starch is not at all soluble in cold water. The mucoso-saccharine matter exists in the farina of wheat only in a very small proportion. It may possibly be more copious in the farina of some other vegetable substances.

However small the proportion of this substance in the farina of wheat, yet there can be no doubt of its acting a peculiar part in the fermentation which takes place in paste, and causes it to rise. The nature of this motion, so necessary to render bread wholesome, is still but very little known. It would appear to be nothing more but

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the beginning of a putrid fermentation in the gluten, an acid fermentation in the ſtarch, and perhaps a ſpiritous fermentation in the mucoſo-ſaccharine matter. Theſe three incipient fermentations, which mutually oppoſe each other, are perhaps what produces the compound, ſo much lighter than dough, which, by baking, and a proper expoſure to heat, forms bread. One thing certain is, that in bread all the three ſubſtances which we have here examined, are found exiſting together, but ſo much altered, that they can no longer be extracted ſeparately. Even the action of heat alone, without the motion of fermentation, is ſufficient to change the nature of theſe three ſubſtances, and combine them in ſuch a manner, that even from bread, unleavened, or baked without being raiſed, Malouin and M. Poulletier tells us, the gluten can no longer be obtained.

From theſe particulars, we underſtand how that all flour but that of wheat, and ſtill more the leguminous or farinaceous ſeeds, ſuch as beans, peaſe, cheſnuts, &c. are far from poſſeſſing the qualities requiſitefor making good bread.

CHAP.

CHAP. XVIII.

Of Vegetable Colouring Matters, and their Application to the Art of Dyeing.

VEGETABLES contain colouring matters through all their organs. Thefe matters are extremely various. It often happens, that a vegetable matter, which has of itfelf no apparent colour, affumes a very diftinct one when expofed to the action of certain menftrua. The art of dyeing, all the proceffes of which are entirely chemical, is founded on the knowledge of the folubility of thefe colouring parts of vegetables, in various menftrua,—of the way of applying them, fo as to communicate colour to other fubftances,—and of rendering them permanent and tenacious on thofe fubftances. In examining the properties of each of the colouring matters, we will have occafion to give fome account of the principles of this important art, on which Meffrs Hellôt, Macquer, le Pilcur d' Apligny,

Hecquet d' Orval, and the Abbé Mazéas, have already published excellent works.

It appears that the colouring matter of vegetables, properly so called, is still unknown. Rouelle was of opinion, that the green part, so copious in the vegetable kingdom, was similar in nature to the gluten of the farina. But it is certain, that this matter exhibits different chemical characteristics, according to the diversity of the bases with which it is united. It is therefore rather the base than the colouring part itself of which we speak, when we say, such a colour is extractive, and such another colour resinous, &c. The substance which really colours those parts of vegetables that are employed in the arts is no doubt a very subtle body, perhaps not less so than the principle of smells. There is even some reason to think, that it consists solely in a certain modification of the solid and liquid parts of vegetables.

It may be proper to recollect here, that the colouring of vegetables depends, in a great measure, on the contact of light. But in what manner the contact of light contributes to the production of colours, is a problem of which the researches of the natural philosopher have as yet afforded no solution. However that may be, as it is impossible to separate the colouring matter entirely from the vegetable base to which it is united, it is generally agreed to consider these two substances together as the colouring matter of plants.

Of all chemists, Macquer has best distinguished the nature of the different colouring matters of vegetables, considered with respect to the art of dyeing: And his theory concerning the application and the fixation

of colours on other ſubſtances in dyeing, is beyond a doubt the moſt ſatisfactory. As I intend here to connect this theory of dyeing with the hiſtory of the chemical properties of the colouring parts of vegetables, I ſhall begin with the conſideration of thoſe properties.

1. A great many vegetable colouring matters, which are either extractive or ſaponaceous, diſſolve very readily in water. Baſtard rocket, madder, logwood, redwood, and Braſil wood, afford yellow or red colours of this ſort. It is eaſy to ſee, that matters dyed with theſe colours muſt loſe their dye in water: on this account, there is employed, to render theſe colours permanent, ſome additional matter capable of fixing and decompoſing them; ſuch as crude tartar, alum, and other ſalts. Theſe ſalts are called *mordants*. A ſolitary acid might produce the ſame effect; but would alter the colouring matter. The ſuperfluous portion of the acid of the alum combines with the alkali of the ſaponaceous colouring extract, and occaſions the precipitation of the reſinous part of that extract, which is then inſoluble in water, upon the ſubſtance intended to be dyed. This colouring part, however, which is rendered inſoluble by the alum, or the mordant, is of two kinds. The firſt is very ſolid, and reſiſts the action of air, of ſoaps, and of all the liquors uſed by dyers as proofs. The other is liable to be altered by air, and ſtill more by the proof-liquors: it is called a falſe dye. In order to aſcertain the nature of theſe colours, and the durability of dyes in general, M. Berthollet has propoſed the uſe of the oxigenated muriatic acid. This acid effects, in a very ſhort time, by means of its exceſs of oxigene, what the vital air of

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the atmoſphere takes a long courſe of time to accompliſh: And, by obſerving what quantity of this acid is neceſſary to diſcolour and entirely whiten any died ſtuff, as well as the time which it takes to produce the effect, a judgment may be formed of the ſolidity and the durability of the colours thus ſubmitted to examination.

It is to be obſerved, that wool takes a dye better than any other ſubſtance; and next after wool, ſilk, cotton, and flax, in the order in which they are here mentioned, receive a dye, each of them with more difficulty than the preceding one, and loſe it ſooner.

Thoſe authors who have written upon the art of dyeing have maintained different opinions concerning the way in which colouring matters act on the ſubſtances expoſed to their operation. Many have ſuppoſed, that in proportion as the pores of the ſubſtance to be dyed are more or fewer, greater or ſmaller, the colouring matter is more or leſs completely applied to it; and that the reaſon why wool takes a colour better than ſilk or thread is, becauſe its pores are more open and more numerous than thoſe of either of theſe ſubſtances. But Macquer thinks the true cauſe which renders the application to any ſubſtance more or leſs eaſy, is the relation between the colouring matter and the body to be died, being nearer or more remote. Dyeing, in his opinion, is actually nothing but painting, which ſucceeds and laſts only by virtue of an intimate affinity between the colouring matter and the dyed ſubſtance. That celebrated chemiſt adopted this opinion in conſequence of the numerous experiments which he made in the art of dyeing; which is indeed highly indebted to his diſcoveries.

2. There is another claſs of colouring matters, which ſeem to conſiſt of reſin and ſaponaceous extract. Macquer calls them *reſino-terreous* matters. When theſe matters are boiled in water, the reſinous ſubſtance which they contain is melted, and diffuſed through the fluid, by means of the action of the heat, and the ſolution of the ſaponaceous part: but it is precipitated as the bath or decoction cools. When, therefore, wool, or any other matter, is immerſed in a decoction of mixed colouring matter of this kind, the reſin is ſeparated by cooling; and, without requiring any farther proceſs, fixes on the ſubſtance thus expoſed to it. Not being ſoluble in water, it forms a permanent dye. Colouring matters of this kind are obtained from almoſt all aſtringent vegetables, ſuch as the huſks of nuts, the roots of the walnut-tree, or of dock, ſumach, bark of alder, ſandal wood, &c. Theſe colours are all yellow, and are called by the dyers root-colours. They are generally uſed to form a good ground, on which colours of a higher luſtre may be laid. We may further remark, that the colouring matters, for the application of which no particular preparation, either of themſelves, or of the bodies to which they are applied, is requiſite, afford the ſimpleſt tincture, and are the eaſieſt applied to uſe.

3. The colouring principle of various other ſubſtances exiſts in a matter that is purely reſinous, and inſoluble in water. Several of theſe matters are not ſoluble even in alcohol; but in alkalis they are all diſſolved, and reduced into a ſort of ſaponaceous ſtate, in which they are ſoluble in water.—The following are the principal colours of this ſort uſed in dyeing.

A. The annatto, a kind of fæculum obtained by maceration from the seeds of the *urucu* putrefied in water. This fæculum is deposited during the putrefaction of the substances. It is at first red, but in course of time becomes of a brick-dust colour. Stuffs intended to be dyed with this matter are immersed into a lixivium of this paste, with the *cendres graveleés*, which we are shortly to describe, mixed together in water. Without the assistance of any mordant, there is deposited on the substances immersed into this lixivium a golden yellow, or orange colour, of considerable beauty.

B. The flower of carthamus, or bastard saffron, affords, by the same process, a very beautiful red colour. This flower has two different colouring parts; the one purely extractive, and soluble in water; the other resinous.—To obtain the latter, the soluble part of the carthamus must first be carefully washed away: What remains after the washing must be mixed with the *cendres graveleés*, or soda; this mixture is then to be formed into a lixivium, and employed in dyeing. But as the alkali alters the colouring matter, and tarnishes the colour, the dyed substance is steeped in water, acidified by lemon-juice. This acid seizing the alkali, the colouring matter is left at liberty, in consequence of which it regains its original properties, and becomes red. By a similar process, there is a coloured fæculum obtained from carthamus, which, mixed with briancon-chalk in powder, composes the *rouge* made use of by the ladies.

C. Archil is a paste prepared from moss and lichen, macerated in urine, with lime. The lime disengages the volatile alkali; and this causes the red colour to appear. Archil diluted in water communicates a dye without any

other preparation. It gives a violet colour; but this is a falſe dye, which is altered in the air, and rendered yellow by the action of acids.

D. Indigo, thecolour of which is a deep violet blue, ſeemingly of a cupreous nature, is a fæculum prepared at St Domingo, and in all the Antilles, &c. by macerating the ſtalk of the *antillo*, or indigo plant, in ſtone troughs, with water. The water becomes blue; and, after it has been for ſome time violently ſtirred, the fæculum is precipitated. The indigo ſeparated from the water is put into cloths to drain. It is then dried in ſmall wooden boxes, and when dry broken into pieces. When it floats on water, and burns entirely away on a red-hot ſhovel, it is eſteemed good. The colouring part of it is extracted by alkalis, and applied to the matters intended to be dyed, without any farther preparation. It cannot be brightened by acids, as theſe would alter the colour.

4. There are certain colouring matters ſoluble in oils. Alkanet, or the red root of a ſort of bugloſs, communicates its colour to oil. Alcohol likewiſe diſſolves ſeveral colouring matters: Green fæcula diſſolve in it as well as in oil. It may be eaſily underſtood, that theſe colours cannot be uſed in dyeing, becauſe the liquids neceſſary to extract them cannot be employed.

Such are the principal facts at preſent known concerning the nature of vegetable colours. From theſe it appears, that any of the immediate principles of vegetables may become the baſe of their colouring parts; as we find them to be ſaponaceous, reſinous, and extractive. Some of them even appear to be of the ſame nature with fixed oils, and are not ſoluble either in water or in alcohol, but diſſolve readily enough in alkali. Laſtly,

There

There are, according to Rouelle, ſome of theſe colouring parts of the ſame nature with the glutinous part of vegetables.

All vegetable colouring matters poſſeſs a more or leſs powerful attraction for oxigene. There are few of them that do not experience a more or leſs ſudden alteration from this principle. The oxigenated muriatic acid alters almoſt the whole of them, and converts them into white or yellow. Moſt part of vegetable colours contain different proportions of oxigene, and frequently owe their ſhades to a difference in the quantity of this principle. This is the reaſon why all theſe colours are prepared with the contact of air, becauſe this contact has a ſingular effect upon their dyes. See M. Hauſeman's Memoir upon indigo (*Journal de Phyſique*, 1788), and my Memoir on the colouring of vegetables by oxigene. Annals of Chemiſtry, Vol. IV.

CHAP. XIX.

Of the Analysis of Plants by Naked Fire.

AFTER examining all the matters which can be obtained from vegetables, by such simple means as produce no alteration in their nature, and considering these matters as the immediate principles of those organized bodies, it will next be proper to consider what alterations they are liable to suffer from fire.

The ancient chemists were acquainted with no other method of analysing vegetables but this; and all their inquiries into the nature of these substances were directed only to discover, how much spirit, oil, and volatile salt, they afforded by distillation in the retort. At present we give but little credit to the results of this process.—We know, that all plants give nearly the same products; and the distillation of a great many different vegetables, by chemists in other respects very skilful and highly respectable, has only served to undeceive us with respect to this analysis. How, indeed, can it be thought, that the action of fire, which is exerted on all the different

ferent principles contained in a vegetable, extract, mucilage, oil, resin, saline matter, gluten, &c. and which decomposes each of them in a peculiar manner, can afford any certain information concerning the nature and the quantity of those principles? especially when we observe, that the products of these different decompositions form, by mutual combination, new bodies, which did not exist before in the vegetable under examination. The analysis of vegetables in the retort is therefore false and complicated.

However, as, in a chemical examination of any substance, we should not refuse the use of any means which art supplies for the discovery of its nature, we may have recourse to this analysis, and observe its effects, provided we be sufficiently on our guard against giving too much credit to its results: Nay, it sometimes happens, that when, in a series of experiments on any vegetable substance, in order to discover its chemical properties, we compare the effects of aqueous, spiritous, and oily menstrua on that substance, with the alterations which it suffers from fire, these alterations accord with the action of the solvents, and shew, by the products of the distillation, what matter is contained in a larger or a smaller quantity in the vegetable, the nature of its salt, &c. But, that we may be able to make such important deductions from an analysis by naked fire, it is requisite, 1. That we be well acquainted with the manner in which fire acts on each of the immediate or proximate principles of vegetables, the extract, the mucilage, the saline matter, the oily juices, fluid or dry, &c. 2. That we compare the products of the distillation of the whole vegetable with those which its proximate principles generally

ly afford when treated in the same manner. 3. That we, at the same time, analyse the vegetable by menstrua, in order that we may distinguish its proximate principles, and draw some useful inferences concerning the alterations which it suffers from fire.

The process necessary for the distillation of vegetables by naked fire, is very easy and very simple.—Put into a glass or earthen retort a certain quantity of the dry vegetable :—care must be taken, however, to fill the vessel only half, or not more than two thirds full. Place the retort in a reverberatory furnace; to its neck adapt a balloon of a proper size. There used to be formerly recommended for this purpose, a balloon perforated with a small hole, to afford a passage for the air which was said to be disengaged, in a smaller or a larger quantity, from the vegetables, and was likely, if confined, to break the vessels. At present we know, that the aeriform fluid which escapes from these bodies, when subjected to distillation, is never air, but rather carbonic acid and hydrogenous gas, with carbonaceous matter dissolved in them. But as these elastic fluids are products of the vegetable, decomposed by the action of fire, as well as the phlegm, the oils, and the volatile salts, it is no less necessary to collect them than these latter substances. For this purpose, there may be employed a perforated receiver, joined to a curved syphon, entering by one end into a bell-glass filled with water, or rather with mercury. By this means, the liquid products are collected into the receiver, and the aeriform products into glass vessels, placed on the shelf of a pneumato-chemical apparatus. When the substance distilled is such

as can afford any concrete ſalt, there is put between the retort and the receiver an adapter, or long glaſs veſſel, in the form of a ſpindle, on the ſides of which the ſalt fixes as it is ſublimated. In this ſort of diſtillation, the fire ſhould be gradually and cautiouſly applied, that the products may be obtained in the order of their volatility, without being confounded together. The proceſs begins with placing a few coals under the retort, and the fire is by degrees increaſed till the veſſel become red-hot, and the paſſing of the products into the receiver appear to have ceaſed. The retort is now ſuffered to cool, the luting removed from the apparatus, and the products examined.

Although the products obtained by the diſtillation of vegetables are never to be entirely depended upon, yet ſo much do they differ from one another, that they well deſerve to be carefully diſtinguiſhed.

The firſt product obtained is an aqueous liquor, impregnated with ſome odorous and ſaline principles. This phlegm aſſumes by degrees more colour, and more ſaline properties. After it, comes a coloured oil, the colour of which becomes deeper, as the proceſs advances. This oil is ſometimes light and fluid, at other times weighty, and liable to become ſolid. It conſtantly exhales a ſtrong empyreumatic ſmell. At the ſame time with it, there is a ſmaller or a greater quantity of elaſtic fluids diſengaged; which are either carbonic acid, or hydrogenous gas, or, which is moſt frequently the caſe, a mixture of theſe two ſubſtances. At the ſame inſtant, too, ammoniacal carbonate is ſublimated, if the nature of the vegetable be ſuch as to afford it. After all theſe matters have

have paſſed, the vegetable is found reduced to a carbonaceous ſtate. Let us now return to a more particular examination of each of theſe products, and attempt to diſtinguiſh what is their nature, and to what ſubſtances they owe their formation.

The phlegm, according to the ancient chemiſts, is owing to the water which enters into the compoſition of the vegetable, and in part to the water of its vegetation; and this eſpecially, when the body analyſed is not entirely dry: and accordingly the quantity of this phlegm is greater or leſs in proportion as the vegetable has been more or leſs thoroughly dried before it was ſubmitted to diſtillation. Several modern chemiſts are of opinion, that the water obtained from the diſtillation of vegetables is formed by the union of hydrogene with the oxigene contained in theſe organized ſubſtances. This phlegm is coloured of a lighter or a deeper red by the ſmall portion of oily matter which it carries off with it, and which is reduced to a ſaponaceous ſtate by the ſalt that is uſually diſſolved in it. The ſaline matter in union with it is moſt commonly acid; on which account this phlegm uſually reddens ſyrup of violets, and produces an efferveſcence with alkaline carbonates. This acid belongs to the mucilages and oils. The phlegm is ſometimes of an alkaline nature, as in the diſtillation of nitrous and cruciform plants, and of emulſive and farinaceous ſeeds. It is frequently ammoniacal; becauſe the ammoniac which follows immediately after the acid combines with it. Of this fact full evidence may be obtained, by throwing a little fixed alkali or quicklime

lime into the phlegm: When it is ammoniacal, there is a lively ſmell of ammoniac diſengaged from it.

The oils obtained from vegetables by diſtillation in a retort are all ſtrong-ſmelling and high-coloured, and exhibit all of them nearly the ſame properties. Thoſe parts of vegetables which contain a great quantity of theſe inflammable fluids, ſuch as emulſive ſeeds, afford, when analyſed, a good deal of oil. The odorous plants afford an oil, which, in the beginning of the proceſs of diſtillation, retains ſomewhat of their ſmell, but ſoon aſſumes the common characteriſtics of all theſe oils; that is to ſay, the colour, gravity, and empyreumatic ſmell, by which they are diſtinguiſhed. All of theſe fluids are highly inflammable; the nitrous acid cauſes them to flame: they are ſoluble in alcohol, and bear, all of them, ſome reſemblance to the vegetable from which they were obtained. By rectification, they may all be rendered very fluid, very light, colourleſs, ſoluble in alcohol; in a word, they may thus be reduced to the ſtate of æthereal or volatile oils.

Theſe empyreumatic oils are formed by the action of the fire, and had no previous exiſtence in the vegetable.

With reſpect to the volatile ſalt, which is nothing but ammoniacal carbonate, it is obtained only from a few vegetables; but we muſt not imagine, as has been advanced by ſome chemiſts, that it is to be obtained only from cruciform plants. All plants, in general, containing a certain quantity of glutinous or vegeto-animal matter, afford more or leſs ammoniac; becauſe, as has been fully proved by M. Berthollet, that principle of

vegetables always contains azote. It very ſeldom happens, however, that any quantity of it can be obtained in a concrete ſtate: it is often diſſolved in the laſt portions of the phlegm. This ſalt is produced by the union of the azote with the hydrogene of the oil; on which account, it does not uſually paſs till the end of the diſtillation. It even appears, that what is carried up by the phlegm in the analyſis of ſome plants, ſuch as the cruciferous plants, poppy, rue, &c. is always the product of ſome new combination; for Rouelle the younger has ſhewn, that the plants themſelves do not contain it in their natural ſtate.

The elaſtic fluids which are diſengaged during the diſtillation of vegetables, are to be included among the products that may be obtained from them. Their nature appears to depend on the nature of the vegetable. A plant which contains a good deal of oily combuſtible fluids, affords hydrogenous gas. Mucilages, on the contrary, afford carbonic acid. We have mentioned, under the article Oxalic Acid, that Meſſrs Bergman and Fontana have obtained from them a large quantity of carbonic acid, and that Fontana thinks vegetable acid to be compoſed chiefly of it. It is therefore not at all ſurpriſing, that mucilages, in which Bergman found the ſame radical acid as in ſugar, ſhould afford carbonic gas when analyſed. Laſtly, There are ſome vegetable matters which afford azotic gas. Theſe aeriform fluids paſs only towards the end of the proceſs of diſtillation; becauſe they are not diſengaged till the inſtant when the vegetable is totally decompoſed. Hales, who was not acquainted with their nature, obſerved, that the

more ſolid the vegetable, ſo much the greater was the quantity of the air diſengaged from it during its diſtillation: and he of conſequence conſidered that element as the cement which produced the ſolidity of vegetable bodies. From what we have had occaſion to ſhew, the reader may eaſily judge of the truth of this hypotheſis.

CHAP. XX.

Of Vegetable Coal, or Charcoal.

CHARCOAL is the black refidue of vegetable matters, whofe volatile principles have been entirely decompofed in clofe veffels. None but organic matters, containing the combuftible fubftance known by the name of oil, afford charcoal. The production of the fubftance which we are beginning to confider, ufed to be afcribed to the decompofition of this latter fubftance; but it is now beginning to be underftood as a fact, that the carbonaceous matter exifts ready formed in the vegetable; and that which is accomplifhed by the operation of fire, is the feparation of the volatile principles that exifted in union with it.

Charcoal is generally black, brittle, fonorous, and light. If the vegetable of which it has been formed was very compact, and contained but a fmall proportion of fluid fubftance, it ftill retains a vegetable form. But again, when the plant decompofed is tender, and contains

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a good deal of juice, the fluids, as they are disengaged, destroy the organic texture of the vegetable, and leave a friable coal, which exhibits not the form of a decomposed vegetable. Different vegetable matters afford coal in greater or less abundance, according to the solidity, and the form of their texture. Wood affords much more of this substance than herbs; gums afford more than resins; and resins more than fluid oils. Every different vegetable matter appears to contain this substance in a particular proportion,—if we consider charcoal as one of the immediate principles of vegetables.

Charcoal is a body possessed of singular properties, which are in general but very little known.—Though it be of the highest importance in chemistry, and exhibit phænomena entirely of a singular nature, yet no chemist has as yet engaged in a series of experiments with a view to ascertain its nature. Stahl, who paid more attention to it than it has since obtained from any other person, thought it the principal repository of phlogiston. We know scarce any thing concerning the properties of charcoal, but what relates to the œconomical purposes to which it is applied: the labours of the learned afford no full information concerning it.

The physical properties of charcoal are different, according to the nature and the state of the vegetables from which it is formed. It is sometimes hard, and retains in some degree the organization of the vegetable; at other times it is friable, and somewhat pulverulent. Pure oils afford a coal in very fine, and seemingly levigated molecules, called lamp-black. Its gravity varies in like manner. When well made, it has no perceptible

taste or smell. Its colour is subject to as many varieties as its other physical properties; it is either of a lighter or a deeper, a sparkling or a dull colour. But the chemical properties of this product of fire, deserve the most particular examination.

Charcoal exposed in close vessels to the utmost violence of fire, suffers no alteration. When heated in a pneumato-chemical machine, it affords no hydrogenous gas, unless it happen to contain moisture: an intense heat reduces it to vapours. When heated in contact with air, it burns it to ashes; but with singular phænomena, which are to be carefully distinguished from those of other combustible matters. As soon as it takes fire, it becomes red, and exhibits a white flame, which is more considerable in proportion as the mass of charcoal is larger. No sort of smoke exhales from it; but it is reduced into carbonic acid, an elastic fluid, which, from the fine experiments of M. Lavoisier, appears to be nothing but a combination of the carbonaceous principle with the oxigenous—of the latter of which principles three fourths of it consist. It is on this account that charcoal consumes slowly, and leaves nothing but a cinder, more or less white, partly of a saline, and partly of an earthy nature. Different sorts of charcoal are of different degrees of inflammability; and this distinction is the most useful to the arts of all the facts respecting charcoal. Some sorts of it burn readily with flame, and are quickly consumed; others are difficult to kindle, burn but slowly, and remain a long time red-hot, before being reduced to ashes. Some of them,—for instance those of oils,—burn indeed, but with the utmost difficulty. This property they seem to owe to the ob-

stinate

stinate adhesion of the carbonaceous principle to the fixed salts of the vegetables; and as the proportion of these last varies in each vegetable, the density of the charcoal, and the quantity of residue which it leaves after combustion, depend on this cause.

Charcoal, when exposed to the air, attracts moisture; probably because it is very porous; and perhaps, too, on account of its containing salts, though these salts be not in a disengaged state. When moistened, it affords hydrogenous gas, which is produced by the decomposition of the water: for, when this fluid is passed through an earthen tube, filled with red-hot charcoal, the two bodies are converted into hydrogenous gas and aeriform carbonic acid. Nothing now remains but a little ashes. Rouelle has taken notice, that fixed alkali dissolves a pretty considerable quantity of charcoal by fusion.

The sulphuric acid, when exposed to a strong heat with powder of charcoal, is decomposed by this combustible body, which has a stronger affinity with oxigene than sulphur has.

The nitric acid is decomposed with much more rapidity by charcoal. Dr Priestley observed, that there was a good deal of nitrous gas produced from this mixture. Macquer saw the nitric acid, with the help of a certain degree of heat, produce a very discernible effervescence with this body. M. Proust has succeeded in kindling charcoal with acid of nitre, the weight of which was one ounce four drams and twenty-three grains, in a bottle containing an ounce of distilled water. The result of his experiments is of no small importance: And I shall therefore here insert an account of them in his own words, taken from his Observations on Pyrophori

without alum, &c. inserted in the *Journal de Medicine*, for July 1778.

" A coal of the extract of carthamus, reduced to " powder, and newly calcined, detonized in a very lively " manner with the nitrous acid; and the combustion " was so rapid, as to raise the powder in the form of a " very beautiful sky-rocket. I calcined, likewise, very " fine powder of common charcoal; and the detonation " succeeded very well.

" Into a glass retort, perfectly dry, I introduced about " a dram of powder of charcoal; after which I poured " into the same retort about as much nitrous acid: " the nitrous acid no sooner reached the bottom of the " retort, than a detonation was produced with the ut- " most rapidity. There proceeded out of the mouth of " the retort, as I held it in my hand, a stream of flame, " more than four inches in length, carrying with it " some of the powder, and very dark-coloured vapours " of the nitrous acid: The vapours were condensed in- " to a green and somewhat fuming liquor, which pro- " ved to be nitrous acid, weakened by the water which " entered into the composition of that which detonized " first. I poured a new quantity of nitrous acid on the " coal which still remained in the retort, and continued " to inflame it in the same way, till the whole quantity " was exhausted.

" This experiment I repeated with calcined lamp- " black; the same phænomena were exhibited. In the " retort there remained only a very small portion of " ashes, sometimes half vitrified, and sticking to the bot- " tom of the retort.

" All

"All charcoal is usually impregnated with a consider-
"able quantity of moisture. I found that charcoal cal-
"cined in the evening was next day unfit for this de-
"tonation, having acquired, during the intervening space,
"a sensible quantity of moisture. But, what is very
"singular, these experiments are so capricious, that they
"do not always succeed, even with the same charcoal,
"and the same acid, intermixed in the very same pro-
"portions. By the following expedient, I believe, suc-
"cess may be secured: When the acid is poured on
"the middle of the charcoal, it does not take fire at all;
"but, again, when the acid is made to trickle down the
"sides of the crucible or capsule, till it reach the bot-
"tom, then detonation infallibly follows, and the pow-
"der is raised and kindled by the nitrous acid. When
"the nitrous acid is all consumed, the detonation
"ceases of course, and the rest of the charcoal remains
"black."

We know nothing concerning the action of the other acids on charcoal.

This body, with the help of heat, decomposes all sulphuric salts, forming in consequence sulphures with various bases.

Charcoal causes nitre to detonize; the nitre burns it by means of the vital air which this saline substance affords by the action of fire. There is a preparation made for the purposes of chemistry and pharmacy, which is called *nitre fixed by charcoal.* Mix two parts of nitre with one of powder of charcoal; put the mixture into a red-hot crucible: A lively detonation immediately takes place: And, when this detonation ceases, there

 remains

remains a white mafs, which attracts moifture from the atmofphere, and is nothing elfe but the fixed alkali of the nitre and the charcoal combined with carbonic acid. On lixiviating this matter, the water diffolves the fixed alkali; and what remains is a fubftance thought to be of an earthy nature.

Sulphure of potafh diffolves charcoal with great facility, both by the dry and by the humid way: it even combines with it more readily than any other fubftance. We owe this difcovery to Rouelle.

Metals do not combine with charcoal; but metallic oxides are reduced, when expofed in contact with this body, to heat more or lefs intenfe. We have already feen, under the article of Metals, that this phænomenon is owing to the ftrong affinity between oxigene and pure carbonaceous matter.

The action of vegetable fubftances on charcoal has been but little examined. We know only, that charcoal mixed with fat oils, renders them fufceptible of inflammation by the nitrous acid; a fact which confirms Rouelle's beautiful theory concerning the inflammation of oils by that acid.

Within thefe few years, charcoal has been alledged to be very proper for whitening and purifying vegetable liquors, when heated along with them.

All that has been here faid concerning the known properties of charcoal, tends to prove that this body is a compound of a combuftible matter, faline fubftances, and earths.

The peculiar combuftible matter which conftitutes ; than three fourths of the compofition of charcoal,

or

or pure carbonaceous matter, is but little known. It appears only to be one of thoſe bodies which have the greateſt affinity with oxigene; ſo great indeed, that it is capable of ſeparating it from every other ſubſtance; and that, in certain circumſtances, it exhibits properties much the ſame with thoſe of native *carbure* of iron.

The uſes of charcoal in the arts are ſufficiently known; it is likewiſe of great uſe in chemical operations.

CHAP. XXI.

Of the Fixed Salts and Earths of Vegetables.

WHEN a vegetable coal is burnt, there remains a grey, blackiſh, or white matter, according to the nature of the coal. This ſubſtance, which is called *aſhes*, is of a very compound nature. When the charcoal is thoroughly burnt, it contains only different ſaline and earthy ſubſtances, mixed with a little iron and a little manganeſe. When, again, the charcoal does not burn very freely, the aſhes produced from it ſometimes contain a little inflammable matter which has not been conſumed. M. Lavoiſier, on examining the aſhes of the wood made uſe of by the manufacturers of ſaltpetre, found it to contain extractive and reſino-extractive matters. The ſaline ſubſtances obtained by lixiviation from the aſhes of charcoal, have received the name of the Fixed Salts of Plants. There are three ſorts of ſalts obtained by the incineration of vegetables, the nature of which we ſhall here deſcribe.

1. Potash, which is prepared in the north by burning wood, which they there possess in great plenty. This salt is very impure; it often contains combustible matters by which its whiteness is impaired, a variety of neutral salts, such as sulphate of potash soda and lime, muriate of potash and of soda, a little carbonate of soda, oxide of iron, and earthy matters. To purify this salt, and extract from it pure potash, it is dissolved in the smallest possible quantity of cold water. The fluid takes up the alkali, with some neutral salts; and the earth, charcoal, iron, and sulphate of lime which the potash frequently contains, are separated by filtration. The solution is evaporated to a pellicle, and then suffered to settle and cool, in order that the different neutral salts which it contains may be formed into crystals. When, at length, after repeated filtration, evaporation, and crystallization, the lixivium ceases to afford neutral salts, it is evaporated to dryness, and calcined. The salt thus obtained is carbonate of potash, intermixed with caustic potash. It always contains, however, some neutral salts, and a small portion of earthy matters, which may be separated by forming these salts and earthy matters into a strong solution with water, suffering that solution to settle and rest for some time, and then separating, by filtration, the sediment thus formed. The potash may now be used with confidence as pure, even in the nicest chemical experiments.

2. Soda is the residue remaining after the combustion of certain plants which grow on the sea-shore. It is prepared at Alicant, in Languedoc, at Cherbourg, &c. by the combustion of various plants. At Alicant, the kali is employed; at Cherbourg, the algas and fucus, commonly known by the name of *varech*. The

former of theſe plants contains a good deal more ſoda than the other; which indeed affords but very little. Theſe plants are made very dry, and burnt over a trench. At Cherbourg, when the combuſtion is conſiderably advanced, and the aſhes are become very hot, they are violently ſtirred and kneaded together with large poles. By this motion, the ſubſtance, being hot enough to ſuffer a ſort of ſemi-vitrification, is formed into ſolid, hard pieces, which are ſold in commerce under the names of *ſtone-ſoda*, *ſalicore*, *ſalicote*, *la marie*, and *alun catin*. The names by which it is chiefly diſtinguiſhed, and which denote its particular ſtate, are thoſe either of the country from which it comes, or the plant from which it is obtained. The ſoda of Alicant, called alſo *barilla*, is the beſt for the purpoſes of chemiſtry, and of all thoſe arts in which fixed alkali is neceſſary.

The ſoda of Cherbourg, or *varech*, contains leſs alkali, and ſhould not be uſed in chemiſtry; but in glaſs-works it is very advantageouſly employed; for it contains vitreous frit, which anſwers the purpoſes of the glaſs-maker, by promoting the vitrification of the other matters.

Common ſoda, chemically conſidered, is a compound of cauſtic ſoda, carbonate of ſoda, a ſmall proportion of carbonate of potaſh, ſulphate of potaſh and ſoda, muriate of ſoda, charcoal, iron in the ſtate of *Pruſſian blue*, as has been obſerved by Henckel, and earth partly free, partly combined with fixed alkali, as in that of Cherbourg. To ſeparate theſe ſubſtances, and obtain the carbonate of ſoda in a pure ſtate, they are formed into a lixivium with cold diſtilled water: this lixivium is filtrated, in order to ſeparate the earth, the iron, and the

carbonaceous

carbonaceous matters: lastly, it is evaporated in the same way as potash. This alkali is more easily purified than potash; for as it crystallizes sooner, it separates more readily from the caustic soda. It however carries with it, when it crystallizes, some of the neutral salts and the Prussian blue contained in the lixivium, which can be separated only by repeated solution, and successive crystallization.

3. There are fixed salts prepared in pharmacy, which have been strongly recommended by Takenius, and still bear his name. This chemist's process consists in putting the plant from which the salt is meant to be extracted into an iron pot, and heating that vessel till its bottom become red-hot: the plant is constantly stirred, and exhales a good deal of smoke: at length it kindles: it must now be covered up with a lid, which may suffer the smoke to escape, but extinguish the flame. By this means, the plant is gradually consumed. When reduced to a sort of blackish cinder, it is lixiviated with boiling water; and, on evaporating this lixivium to dryness, a yellowish or brown salt is obtained. This salt is often alkaline, but very impure; it contains a good deal of extractive matter, from which it derives a colour, and which is mixed with all the neutral salts contained in the plant: it is in a sort of saponaceous state, which makes it very fit for being employed in medicine. But we must not imagine that it possesses all the virtues of the plant from which it was extracted; for the combustion necessarily alters the principles of the plant. It would be worth while to examine, by a chemical analysis, the several fixed salts prepared in Takenius's way, in order to discover what saline and extractive substances they contain;

contain; and to aſcertain their virtues, and the quantities in which they are to be adminiſtered.

4. When the aſhes of vegetables are deprived, by lixiviation, of all the ſaline matters which they contained, the reſidue is nothing but a pulverulent ſubſtance, more or leſs white or coloured, inſipid, inſoluble in water, and which has been hitherto thought to conſiſt of earths.

The magnet attracts iron from this matter. This iron, as well as the manganeſe which has in like manner been for ſome time obtained from this reſidue of vegetables, muſt have exiſted ready formed in the plant. A number of naturaliſts are of opinion, that plants owe their colours to iron. M. Baumé, who, in his Memoir on clays, mentions the earthy reſidue of vegetables, affirms, that it forms, with the ſulphuric acid, alum and ſulphate of lime, a little different from that which owes its formation to pure calcareous earth. From this M. Baumé concludes, that the earth of vegetables conſiſts of alumine, and of another earth, nearly of a ſimilar nature with calcareous earths; yet diſtinct from theſe, as it does not form quick-lime by the action of fire. He thinks that alumine is formed in theſe ſubſtances by the colliſions to which ſiliceous earth is expoſed in them, and by the action of the acids with which it combines; and that alumine, once formed, paſſes into the ſtate of calcareous earth, in conſequence of undergoing new elaborations in the tubes of vegetables.

We cannot help obſerving in this place, that the diſcoveries made in Sweden concerning the ſaline nature of the bones of animals,—which are to animals preciſely what the fibrous texture of plants is to vegetable bodies,

dies,—seem to ſuggeſt, that the reſidue of vegetables is any thing rather than an earth. Perhaps an exact analyſis, ſuch as has not yet been made, might ſhew, that what has been taken for an earthy matter, is rather calcareous phoſphate; at leaſt we may ſuſpect as much from the experiments of Margraff and M. Berthollet, who have obtained phoſphorous from the grains of muſtard, from the gluten, and from various other vegetable matters;—as well as from the experiments of M. Haſſenfratz, who has extracted phoſphoric acid from a great many marſh plants.

CHAP.

CHAP. XXII.

Of Fermentations in general, and of the Spirituous Fermenation in particular.

AFTER confidering vegetables in the ftate in which nature prefents them to our obfervation, we may attend to the alterations and changes which they are liable to fuffer from various circumftances. Thefe alterations depending entirely on their nature, are always the effect of a phenomenon, called *fermentation.*

Fermentation is a fpontaneous motion which arifes in vegetables, and fometimes produces a total change of their properties. This motion is peculiar to the fluids of organic bodies; and no fubftances, but fuch as have been elaborated by the functions of vegetable or animal life, are fufceptible of it. Chemifts have not infifted fufficiently on this important truth, the application of which to the phænomena of organized fubftances is fingularly ufeful in medicine.

There

There muſt ſeveral circumſtances concur to promote this fermentation. Such as,

1. A certain degree of fluidity. Dry ſubſtances ſuffer no ſort of fermentation.

2. A more moderate or a more intenſe heat. The degrees of heat vary with the ſorts of fermentation; but cold ſtops the progreſs of every kind of fermentation.

Boerhaave, and after him other chemiſts, have diſtinguiſhed fermentation into three kinds: Spirituous fermentation, which produces alcohol;—acetous fermentation, which affords vinegar or acetous acid;—and putrid fermentation or putrefaction, which produces ammoniac. It is to be obſerved, that there are ſeveral fermenting motions, which cannot be referred to any of theſe three claſſes of fermentation.—Such, perhaps, are the fermentations of bread, of inſipid mucilages, of colouring matters, &c. It has been thought, that fermentations always ſucceed each other in the order in which we have mentioned them: but there are bodies which become acid, without paſſing previouſly into the ſtate of putrefaction; and, in other inſtances, putrefaction takes place without being preceded by the two other ſpecies of fermentation.—We may likewiſe obſerve, that the internal motion of maturation ſeems to conſtitute a ſpecies of primary fermentation, which calls forth the ſaccharine matter from a latent ſtate. It is ſpirituous fermentation which affords alcohol. In order to become well-acquainted with the phænomena of this ſpecies of fermentation, we may conſider, 1. The conditions neceſſary to its productions; 2. The phænomena which accompany it; 3. The ſeveral matters ſuſceptible of it;

4. The caufe of this internal motion; 5. The product which it forms.

It is well known to chemifts, that all vegetable matters are not fufceptible of fpirituous fermentation, and that, in order to its taking place, feveral different circumftances muft concur. Thefe we are to confider as neceffary conditions of fpirituous fermentation.

Thefe conditions are,

1. A faccharine mucilage. No other matter is fufceptible of fpirituous fermentation.

2. A fomewhat vifcous fluidity. Too fluid a juice is no more fufceptible of fpirituous fermentation than one that is too thick.

3. The heat of—from ten to fifteen degrees in Reaumur's, or from fifty-five to fixty-five of Fahrenheit's.

4. A confiderable mafs of matter in which a rapid motion may be excited.

When thefe four conditions concur, fpirituous fermentation then takes place; and certain phenomena invariably accompany it. The following are what have been difcovered by obfervation concerning it.

1. A motion is raifed in the liquor, which becomes more and more confiderable, till at length the fermentation is fairly eftablifhed through the whole mafs.

2. The bulk of the mixture is confiderably enlarged, in proportion as the motion is communicated through the whole mafs.

3. The liquor lofes its tranfparency, and is rendered turbid by opaque filaments appearing in motion through all parts of it.

4.

4. There is a heat produced, amounting, according to the Abbé Rozier, to eighteen degrees of Reaumur, or ſeventy-two and one half, Fahrenheit.

5. The ſolid parts intermixed with the liquor are raiſed, and ſwim, in conſequence of the diſengagment of an elaſtic fluid.

6. There is a conſiderable quantity of carbonic acid gas diſengaged. This gas forms a ſtratum above the liquor in the veſſel containing it, which may be eaſily diſtinguiſhed from common air. It was on air thus produced, that Dr Prieſtley and the Duke de Chaulnes made their fine experiments. It extinguiſhes lights, and proves fatal to animals. It produces from lime-water a chalky precipitate: Cauſtic alkali it cauſes to cryſtallize perfectly. This acid is what renders the employment of thoſe who are engaged in conducting fermentation ſo very dangerous to health.

7. The diſengagement of this gas is attended with the formation of a great many bubbles, which depend on the viſcidity of the liquor through which the carbonic acid muſt paſs.

All theſe phænomena ceaſe by degrees, as the liquor loſes its ſweet taſte and saccharine nature, and becomes briſk, pungent, and capable of producing intoxication.

Men have been taught by neceſſity to prepare fermented liquors from many different vegetable ſubſtances. But experience has evinced, that none but ſaccharine matters are properly ſuitable for this purpoſe. The ſaccharine matters which are moſt commonly uſed in the preparation of fermented liquors, and which therefore beſt deſerve to be examined here, are the following:

1. The juice of the grape, properly so called, produces wine, the best of all fermented liquors. In learning the art of cultivating vines, which is of great importance, it will be proper to examine, 1. The nature of the soil on which the vine grows; a dry parched soil is known to be very favourable to this plant, as it does not thrive well in a strong fat soil:—2. The mode of managing and cultivating this vegetable; it is to be pruned, and its branches bent down, to retard the progress of the sap. Care must by taken to have the vine exposed to the sun, particularly to the reflection of his rays from the ground, &c.; and it does not need to be supplied with any sort of manure, &c.:—3. The history of the vegetation of the vine, its exposure, its flowering, and the formation and ripening of the grape:—4. That of the accidents to which it is liable from frost, rains, moisture:—5. The season of the vintage, which should be dry and hot. When this previous knowledge is acquired, the art of making wine is next to be considered; which consists in putting the grapes, after pulling them, into a vessel exposed to the heat of fifteen or sixteen degrees, and crushing, stirring, and turning them: fermentation is then produced, with all its usual phænomena. The juice of the grape, or must, should not be either too fluid or too thick; when too fluid, it may be thickened by boiling; when too thick, it must be diluted with water. When the wine is made, it is drawn off, and put into open casks. It there suffers insensibly a second fermentation, by which its principles are more intimately combined. It precipitates a fine lee, and a salt known by the name of *tartar*, which we have examined in a former chapter of this volume. To preserve wine,

rags

rags dipped in ſulphur are burnt in the caſk in which it is contained.

It is farther of importance, to be able to diſtinguiſh the different ſorts of wine. France produces a great variety of excellent wines: thoſe of Burgundy are the beſt for conſtant uſe: their principles are ſo perfectly combined, that none is predominant over the reſt. The vines of the diſtrict of Orleans acquire nearly the ſame qualities with thoſe of Burgundy, when time has mellowed their harſhneſs, and ſubdued the exceſs of ſpirit or alcohol which they contain. The red wines of Champagne are very excellent, and of a delicate flavour. The white wine of the ſame country which does not ſparkle, is much better than that which ſparkles; for the taſte of the latter is tart and ſouriſh; and it owes its quality of ſparkling to its containing carbonic acid, in conſequence of having been bottled before the fermentation had been finiſhed. The wines of Languedoc and Guyenne are deep coloured, and highly tonic and ſtomachic; eſpecially when old. The wines of Anjou are ſtrongly ſpirituous, and therefore ſoon intoxicate. As to foreign wines, thoſe of Germany, known by the name of *Rheniſh* and *Moſelle* wines, are white, very ſpirituous, and of a freſh poignant taſte: They very ſoon intoxicate. Some Italian wines, ſuch as thoſe of Orvietto, Vicenza, and Lachryma Chriſti, &c. are well fermented, and not much inferior to good French wines. Thoſe of Spain and Greece are, in general, ſweet, crude, imperfectly fermented, and very unwholeſome. We muſt, however, except thoſe of Rota and Alicant, which are deſervedly eſteemed very uſeful ſtomachics and cordials.

2. Apples and pears afford cyder and perry: These are pretty good liquors; and M. D'Arcet has shown, that brandy may be obtained from them.

3. Cherries afford a pretty good wine, from which that species of brandy which the Germans call *kirchen-wasser* is extracted.

4. Apricots, peaches, and plums, afford a species not quite so good.

5. Sugar dissolved in water easily ferments. From this sort of wine, prepared from the juice of the cane, there is a spirit extracted, which is known by the names of *taffia*, *rum*, *guil dive*, &c.

6. Gramineous seeds, and of these especially barley, afford a sort of wine, called *beer*. The following are the processes of the art of brewing: The barley is steeped in water for thirty or forty hours, to soften it. It is then laid in a heap, and left in that state till it begin to germinate. It is then dried in a kiln; and the buds are separated by sifting: after which, it is coarsely ground into what is called *malt*. The malt is put into a vessel, called the *mash-tun*, and hot water poured upon it to dissolve the mucilage. This being drawn off, a second quantity of hot water is poured upon the malt; and in like manner drawn off. This fluid is called *wort*, and boiled with hops; after which it is put to ferment, with yeast, into a vessel called the *cooler*. When the fermentation begins to subside, the beer is stirred, and drawn off into casks. The second fermentation throws up a scum called *yeast*, which is kept for fermenting future brewings. Germination calls forth, from a latent state, a certain saccharine matter in barley, to which

which malt owes its property of affording a wine. A fimilar liquor might be prepared from moft other gramineous feeds.

All thefe facts concur to fhow, that the faccharine matter is the only principle of vegetables fufceptible of fpirituous fermentation, and that water is neceffary to the production of this inteftine motion. Modern chemifts are of opinion, that vinous fermentation confifts folely in a change of the proportion of the faccharine principles. A great part of the oxigene combines with the carbonaceous matter, to form the carbonic acid that is difengaged during the fermentation; whilft the hydrogene, combined with a fmall portion of carbone, forms a very light and fubtle combuftible body, which contains much lefs carbonaceous matter than fugar, and is much lighter, and much more inflammable, and conftitutes what is called *alcohol.*

The product of all thefe fermented fubftances is a peculiar liquor, more or lefs coloured, of an aromatic fmell, of an hot, poignant tafte; which, when taken in a fmall quantity, re-invigorates the fibres, and, when drunk in too great abundance, intoxicates; and is known over all the world by the name of *Wine.*

The wine of grapes, for inftance, is a compound confifting of a large proportion of water,—an aroma, peculiar to each different fort of wine,—alcohol,—an effential falt, called *tartar,*—and an extracto-refinous colouring matter, to which red wines owe their colour.

Before proceeding to explain the means by which thefe principles may be feparated, it may be proper to give

ſome account of the properties and uſes of pure unaltered wine. Wine, by means of the water, alcohol, and eſſential acid ſalt which it contains, is capable of diſſolving a great many bodies. It unites with extracts, reſins, certain metals, &c. Theſe are the properties which render wine fit for entering into medical preparations. Theſe preparations are, 1. Emetic wine, which is prepared by macerating four ounces of *crocus metallorum* in two pounds of good white wine. The liquor is filtrated, or elſe made uſe of in a turbid ſtate, as a powerful ſtimulus in caſes of apoplexy, palſy, &c.—2. Chalybeate wine, prepared by digeſting an ounce of iron-filings with two pounds of white wine. It is an excellent tonic and aperient.—3. Vegetable wines, which are prepared, A, either with red wine, in which aſtringent aromatic plants are macerated; or, B, with Spaniſh wine. Both the wine of ſquills, and the liquid laudanum of Sydenham, are prepared with this ſpecies of wine. The latter of theſe is prepared by digeſting, for a number of days, two ounces of opium cut into ſlices, an ounce of ſaffron, and a drachm of cinnamon and cloves, in a pound of Spaniſh wine. This mixture, taken in dozes of a few drops, is an excellent calming medicine, eſpecially when there is reaſon to fear that opium might weaken the patient too much, or might hinder ſome uſeful evacuation.

The action of fire is commonly uſed to decompoſe wine, and ſeparate its different principles. The liquor is diſtilled in an alembic of copper plated with tin, with a receiver adapted to it. As ſoon as the wine is heated to ebullition, it affords a white fluid, in a ſmall degree opaque and milky, of a hot poignant taſte, and of

a ſtrong ſweet ſmell. This fluid is collected into the receiver, till ſuch time as the vapours exhaling ceaſe to be ſuſceptible of inflammation at the approach of a candle. This product is what is called *Brandy*: It is a compound of water, alcohol, and a ſmall quantity of oil, which obſcures its tranſparency while it is diſtilled, and afterwards communicates to it a yellow colour. The colour of old brandy is not, however, owing ſolely to this oil which paſſes with it when it is diſtilled, but rather to the extractive matter of that part of the wood of the caſks which it has diſſolved. Alcohol, as we ſhall hereafter ſee, is extracted from brandy. Wine, after affording brandy, aſſumes a deeper colour, and a harſh acid taſte; it is alſo turbid, and may be obſerved to contain a great many ſaline cryſtals, which are nothing but tartar. This fluid is now, therefore, totally decompoſed, and its original properties cannot be again communicated to it, by combining the ſpirituous product with the reſidue: The analyſis is therefore complicated. The reſidue of wine from which brandy has been extracted, takes, by evaporation, the form and conſiſtency of an extract. The colouring part may be ſeparated by alcohol, which does not affect the tartar. This tincture is not liable to be precipitated by water. When evaporated to dryneſs, the reſidue readily takes fire, and is ſoluble in water. It is, in its nature, a true reſino-extractive ſubſtance, which the alcohol formed by the fermentation has taken up from the pellicles of the grapes. From this analyſis it appears, that wine is actually compoſed of water, alcohol, tartar, a colouring matter, and an aroma, which is deſtroyed or modified by the action of fire. We already know the nature and properties

of most of these substances: we have only alcohol to examine.

Before we proceed to speak of this product, it will be proper to say something concerning a substance which is precipitated from wine while it ferments, and is called *lees*. It consists of the seeds and skins of grapes, impure tartar, and sulphate of potash, or vitriolated tartar. Brandy is obtained from it by distillation with naked fire. When treated in a retort, it affords an acid phlegm, and ammoniac; and its coaly residue contains carbonate and sulphate of potash. The lees of wine, incinerated in the open air, afford caustic potash, mixed with carbonate and sulphate of potash; a substance known in the arts by the name of *cendres gravelees*. The particulars which we are to relate concerning the properties of alcohol, will complete what has been here said concerning the properties of lees.

Several chemists were of opinion, that the alcohol, in this analysis of wine, was only disengaged by the action of the fire. But if this substance were ready formed in the wine, it would be obtained by a very gentle heat, whilst this can be effected only by ebullition. Thus, modern chemists conceive, that the alcohol is formed by the heat of ebullition, that its principles, *viz.* a large proportion of hydrogene, with a small quantity of carbone, combine together during the distillation of wine; in short, that this liquor contains only the principles of alcohol.

CHAP.

CHAP. XXIII.

Of Alcohol, or the Product of Spirituous Fermentation.

BRANDY, obtained from wine by diſtillation with naked fire, is a compound of alcohol, water, and a ſmall portion of oily matter. Diſtillation is employed to ſeparate theſe ſubſtances, and give the alcohol pure. There are ſeveral proceſſes for the diſtillation of alcohol. M. Baumé recommends the diſtillation of brandy on a balneum-mariæ, to be repeated as often as may be neceſſary for the extraction of all the ſpirit which it contains. He directs, to ſeparate the firſt fourth part of the product of the firſt diſtillation, and, in like manner, the firſt half of the product of the ſucceeding diſtillations; then to mix all theſe firſt products together, and rectify them by a gentle heat. The firſt half of the liquor which paſſes in this rectification, is the pureſt and ſtrongeſt alcohol: the reſt is a weaker alcohol, but ſtill better for ordinary purpoſes. Rouelle directs to extract, by diſtillation on the water-bath, one half of the brandy made uſe of: this firſt product is common alcohol. By recti-

 fying

fying it twice, and reducing it about two thirds of its original quantity, the ſtrongeſt alcohol is obtained: This, according to Kunckel's proceſs, is to be again diſtilled with water, to ſeparate the oil by which it is altered. This alcohol, after the diſtillation with water, is rectified; and the operator is now certain of its being perfectly pure. The reſidue of diſtilled brandy is nothing but water impregnated with ſome particles of colouring matter, with a peculiar oil floating on its ſurface.

It may be naturally inferred, that this fluid being prepared by various proceſſes, will be, at different times, of different degrees of ſtrength. Attempts have long been made to diſcover ſome means of aſcertaining its purity. It was at firſt thought, that the alcohol which burns readily, and leaves no reſidue, muſt be very pure: But it is now known, that the heat produced by its combuſtion is ſufficiently ſtrong to diſſipate all the phlegm which it may contain. Powder has been propoſed as a teſt of its purity. Alcohol that does not kindle gunpowder, when it is itſelf kindled, and applied to it in a ſpoon, is conſidered as bad; but if it does kindle the powder, it is thought very good. This proof, however, is fallacious; for when any conſiderable quantity, even of the beſt alcohol, is poured on a little powder, the water which it affords as it burns, moiſtens the powder ſo as to hinder it from kindling; whereas, again, the ſame powder may be kindled, by burning at its ſurface a very ſmall quantity even of phlegmatic alcohol. This method of proof is therefore not more certain than the former. Boerhaave gives a very good proceſs for aſcertaining the purity of alcohol. It conſiſts in caſting dry powdered

potaſh

potaſh into the alkali under examination. The potaſh enters into union with the ſuperabundant water of the alcohol, and forms with it a more ponderous and a higher coloured fluid, which does not mix with the alcohol, but ſinks under it. Laſtly, M. Baumé, proceeding upon this principle, that the purer alcohol is, ſo much the more does its levity exceed that of water, has contrived an areometer, by means of which the degree of the purity of this, or of any other ſpirituous liquor, may be accurately aſcertained. When that inſtrument is immerſed in alcohol, the purer the fluid is, ſo much the deeper does it ſink. He has aſcertained, by a number of accurate experiments, that the pureſt and moſt highly rectified alcohol gives thirty-nine degrees of his areometer, at ten degrees of Reaumur's thermometer. The method of conſtructing this inſtrument, with the reſults which alcohol afforded when mixed with various quantities of water, may be ſeen in his Elements of Pharmacy, and may be applied to determine the ſtrength of ſpirit of wine by the hydrometer.

Pure alcohol, obtained by the proceſs above deſcribed, is a tranſparent fluid, very moveable, and very light, which weighs ſix drachms and forty-eight grains, in a bottle containing an ounce of diſtilled water. Its ſmell is poignant and agreeable; its taſte hot and pungent. It is exceedingly volatile. When expoſed even to a ſlight degree of heat in cloſe veſſels, it aſcends, and paſſes unaltered into the receiver. By this means it is concentrated; and any little water which it might contain is ſeparated from it. On this account the firſt portions are the ſweeteſt, the pureſt, and the moſt volatile. It was formerly thought, that there was a good deal of air diſ-

engaged

engaged from alcohol when diſtilled; but what was thought to be air is now known to be the ſpirituous part of the fluid, which eſcapes from the water, and is volatilized in the ſtate of gas.

When alcohol is heated in contact with air, it ſoon kindles, and burns with a light flame, the middle of which is white, and the edges blue: if it has been well dephlegmated, it burns in this manner without leaving any reſidue. Various chemiſts have attempted to diſcover what products alcohol afforded when burnt. They have aſcertained, that its flame is not accompanied with any ſoot or ſmoke, and that the products volatilized prove to be nothing but pure water, inſipid, inodorous, and perfectly in the ſame ſtate with diſtilled water. This phænomenon induced Boerhaave to think, that the flame was owing to the water*; and his opinion receives confirmation from what is at preſent known concerning the hydrogenous gas obtained from the decompoſition of water,—and concerning the compoſition of water by the combuſtion of the ſame gas with vital air. M. Lavoiſier, on burning alcohol in a chimney, which was ſo conſtructed and diſpoſed as to collect the vapours, diſcovered, that the quantity of water obtained is greater than the quantity of alcohol burnt; a fact from which it appears, that alcohol contains a great deal of hydrogenous gas. On the other hand, M. Berthollet has remarked, that when a mixture of alcohol and water is burnt, the fluid reſidue precipitates lime-water. This experiment ſhews, that alcohol contains a little carbonaceous matter, which, by its combuſtion, or combination with oxigene, forms carbonic acid. Chemiſts have entertained different opinions concerning its nature. Stahl,

Boerhaave,

Boerhaave, and ſeveral others, have conſidered this fluid as a compound of a very ſubtle oil, with an attenuated acid and water. According to this opinion, therefore, it is a ſort of acid ſoap. Others, at the head of whom Cartheuſer and Macquer deſerve to be named, think alcohol to conſiſt of phlogiſton and water. The true nature of this liquor is not well known; but it is rather conſidered as a particular compound, conſiſting of a large proportion of hydrogene, with a ſmall quantity of carbone.

Alcohol, when expoſed to the air, is evaporated at the temperature of ten degrees above the freezing point, and leaves no reſidue, except a little water, when it has not been ſufficiently dephlegmated. The hotter the atmoſphere, ſo much the more rapid is the evaporation. It is attended with a greater or a leſs degree of cold, according to its rapidity. At 68 degrees of heat above o in Reaumur's thermometer, 185° Fahrenheit, alcohol takes the form of an elaſtic fluid.

Alcohol combines with water in any proportion, and is perfectly ſoluble in it. This ſolution is attended with heat, and forms different ſorts of brandy, the ſtrength of which is in proportion to the quantity of the alcohol. So ſtrong is the affinity of combination between theſe two fluids, that water is capable of ſeparating from alcohol many of the other bodies which may be united with it; and again, alcohol decompoſes moſt ſaline ſolutions, and precipitates the ſalts. On account of its poſſeſſing this property, Boulduc has propoſed the uſe of alcohol to precipitate the ſalts contained in mineral waters, and obtain them without alteration.

Alcohol

Alcohol does not act on pure earths. We know not whether it be liable to be altered by barytes or magnesia. Lime appears to be capable of producing some change upon it; for when alcohol is distilled on this salino-terreous substance, the fluid acquires a peculiar smell. But this phænomenon has not been sufficiently attended to.

The fixed alkalis actually decompose alcohol, as is proved by the preparation known in pharmacy by the name of *acrid tincture of tartar*. In preparing this medicine, a quantity of potash is melted in a crucible, and either pulverized hot, or put into a matrass: highly dephlegmated alcohol is poured to three or four fingers depth above the salt: the matrass is closed with another of a smaller size: these are luted together, and the whole is digested on a sand-bath, till the alcohol acquire a reddish colour. Either more or less alkali remains at the bottom of the vessel. By distilling the acrid tincture of tartar, we obtain an alcohol of a sweet smell, but little altered; and there remains in the retort a matter resembling a saponaceous extract, which, when distilled by naked fire, affords alcohol, ammoniac, and a light empyreumatic oil. After this operation, a little charcoal remains, which is found to contain the potash. From this experiment it would appear, that alcohol contains or forms an oil, which the fixed alkali seizes, and forms with it a real soap that is found in the portion of the alcohol which has not suffered decomposition. The *lilium of Paracelsus* differs from the acrid tincture of tartar, only in that the fixed alkali employed in the preparation of it appears to have been reduced to a caustic state by the metallic oxides with which it was heated.

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The *martial*, *jovial*, and *cupreous* reguli of antimony, of each four ounces, are fused together, reduced to powder, and detonized with eighteen ounces of nitre, and as much tartar: they are urged with fire till they melt; the mixture is then pulverised, put into a matrass, and highly dephlegmated alcohol poured upon it, to the depth of three or four fingers breadth above the powder. This mixture, digested on a sand-bath, assumes a beautiful red colour, deeper than that of the acrid tincture of tartar, and exhibits all the same phænomena. That tincture may be rendered entirely similar to the lilium of Paracelsus, by digesting alcohol on caustic fixed alkali, instead of using fixed salt of tartar, which is not entirely deprived of its carbonic acid by the action of fire, unless it be kept for a long time red-hot. M. Berthollet is convinced that these tinctures are nothing but solutions of caustic potash in alcohol, and they afford an happy mode of obtaining this alkali very pure, as they leave it separate by evaporation. Alcohol acts in the same way on pure soda. The acrid tincture of tartar, and the lilium, are very good tonics, and powerful discussives. They are employed in all cases in which the natural strength of the patient is not sufficient to support the progress of his disease to a crisis, as in the malignant fever, small-pox of a bad kind, &c.

The action of caustic ammoniac on alcohol has not yet been examined.

All the acids exhibit with alcohol phænomena highly worthy of observation. When a quantity of strongly concentrated sulphuric acid is poured on an equal quantity of rectified alcohol, a remarkable heat and hissing take place. The two substances become coloured; and

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there is at the ſame time exhaled from them a ſweet ſmell, reſembling that of lemons, or the apple called the *golden rennet.* If the retort in which this mixture is uſually made be placed on a hot ſand-bath, with two large balloons adapted to it, the firſt being immerſed in a veſſel full of cold water, the products obtained are, 1. A ſweet-ſmelling alcohol. 2. A liquor called æther, of a very ſweet ſmell, extremely volatile, and whoſe preſence is indicated by the ebullition of the liquor contained in the retort, and by the large ſtriæ with which the ſides of the veſſel are furrowed. Care muſt be taken to cool the receiver with wet cloths. 3. After the æther follows ſulphureous acid, the white colour and ſmell of which ſhew that it is time to change the receiver, in order to obtain the æther ſeparate. 4. There is at the ſame time volatilized a light yellowiſh oil, which is called *ſweet oil of wine.* The fire muſt be greatly moderated after the æther has paſſed; becauſe the matter now remaining in the retort is black and thick, and ſwells conſiderably. 5. When the ſweet oil is all diſtilled, there likewiſe paſſes ſulphureous acid, which becomes gradually thicker, till at laſt it is nothing but black and dirty ſulphuric acid. 6. Continuing this operation by a moderate fire, the reſidue is at length ſo much dried as to take the form and conſiſtency of a bitumen. This bitumen expoſed to a very ſtrong fire, affords an acid liquor, and a dry yellowiſh ſubſtance like ſulphur. M. Baumé, who has made a long train of experiments on ſulphuric æther, has examined this reſidue with a great deal of care: He has found in it ſulphate of iron, Pruſſian blue, a ſaline ſubſtance, and a peculiar earth, the nature of which he has not determined.

mined. He even aſſerts, that the yellow ſublimate which it affords is not ſulphur; and that it remains white and pulverulent, without being kindled on the coals. To theſe particulars we ſhall add, that a new quantity of æther may be obtained from the reſidue from which æther has been once obtained, by adding to it, according to M. Cadet's proceſs, one third part of alcohol dephlegmated by potaſh, and diſtilling that mixture. Theſe diſtillations may be ſeveral times repeated; ſo that from a mixture of ſix pounds of ſulphuric acid with alcohol, by adding to it ſucceſſively fifteen pounds of the latter of theſe fluids, more than ten pounds of good æther may be obtained.

The operation which we have been deſcribing is, by the phænomena which it preſents, one of the moſt ſingular, and at the ſame time one of the moſt important, in all chemiſtry, as it affords ſome information concerning the principles of which alcohol is compoſed. There are two opinions concerning the formation of æther; of which it is proper for us to give ſome account. Macquer, who, as has been mentioned, thinks alcohol a compound of water with phlogiſton, is of opinion, that in the formation of æther, the ſulphuric acid, ſeizing the water of the alcohol, brings it nearer in nature to oils. Thus, according to this opinion, there paſſes, at the firſt, alcohol a little altered;—then a fluid of a middle character between alcohol and oil, which is æther;—and, laſtly, a genuine oil; becauſe the ſtronger the heat employed to obtain the æther, with the greater energy does the ſulphuric acid act on the principles of the alcohol. Bucquet, ſtruck with a ſtrong objection which he made to this theory, namely, its being hard to

conceive how the ſulphuric acid, impregnated as it muſt be, from the time when it begins to act upon the alcohol, with a certain quantity of water, abſtracted from that fluid, can, notwithſtanding this dilution, re-act with ſuch force on another part of the ſame alcohol, as to reduce it into an oily ſtate,—has advanced another opinion concerning the production of æther. He conſidered alcohol as a fluid compounded of oil, an acid, and water. He thought, that when the ſulphuric acid was mixed with alcohol, the reſult of the mixture was a ſort of bituminous fluid, which afforded by heat the ſame principles with all the other bitumens,—that is to ſay, a light oil, very odorous, and highly combuſtible; a ſort of naphtha, which was æther; and then an oil, leſs volatile, but higher coloured than the former, which is the ſweet oil of wine. We will in fact ſee, in examining the properties of æther, that this fluid has all the characteriſtics of a very ſubtle oil, ſuch as naphtha. This theory does not afford a ſufficiently clear explanation of what paſſes in the preparation of æther. It appears, that the alcohol deprives the ſulphuric acid of its oxigene;—that a part of the hydrogenous principle contained in the alcohol, combines with this oxigene to form water;—and that the alcohol, after loſing that part of its hydrogene, forms æther. But we are not acquainted with all that paſſes in this operation.

Æther, obtained by the proceſs here deſcribed, is not very pure: It is combined with alcohol and ſulphureous acid. To rectify it, it is diſtilled in a retort, on a ſand-bath, with fixed alkali. This ſalt combines with the ſulphureous acid, and the æther then paſſes very pure by the moſt moderate heat. By ſeparating the firſt half of

of this product, the æther is obtained in the pureſt and moſt highly rectified ſtate.

Æther is a fluid lighter than alcohol, of a ſtrong ſweet ſmell, ſuſceptible of great expanſion, and of a hot and pungent taſte. It is ſo volatile, that when ſtirred or ſhaken, it is diſſipated in an inſtant. When evaporating, it produces a cold ſufficient to freeze water, as M. Baumé has ſhewn by his beautiful experiments. It is reduced into a ſort of æthereal gas, which burns with rapidity. Air in which æther is contained, in a ſtate of ſolution, will paſs through water without loſing its odour or inflammability. Æther is very eaſily kindled, by being heated in the open air, or brought into contact with a burning body; the electric ſpark likewiſe kindles it. It diſplays a very luminous white flame, and leaves a black, and ſeemingly carbonaceous, mark on the ſurfaces of bodies expoſed to its flame. M. Lavoiſier has proved, that carbonic acid is formed during the combuſtion of this liquor; and M. Scheele, that the reſidue of æther burnt on a little water contains ſulphuric acid.

Æther, according to the Count de Lauraguais, is diſſolved in ten parts of water. The phænomena which æther is capable of exhibiting with ſaline ſubſtances, have not yet been particularly examined. We know only how it re-acts on acids. Lime and the fixed alkalis do not appear capable of producing any alteration upon it. Cauſtic ammoniac mixes with it in all proportions, forming with it a matter, the mixed ſmell of which might produce very happy effects in ſpaſmodic complaints. The ſulphuric acid becomes conſiderably hot with æther, and is capable of converting a great part of it into ſweet oil of wine, by diſtillation. The fuming ni-

trous acid excites a conſiderable effervefcence in æther; and æther appears to become higher coloured, and more oily, and to acquire greater conſiſtency, in conſequence of the admixture of this acid. When mixed with the muriatic ſolution of gold, æther retains a part of the metal, acting, it would appear, in the ſame way as volatile oils, which alſo retain a part of the oxide of gold. It diſſolves volatile oils and reſins, like alcohol: And phyſicians often make uſe of æthereal tinctures.

Æther is thought a powerful tonic, and a very good antiſpaſmodic medicine. It is adminiſtered in hyſteric complaints, and in ſpaſmodic colics. It acts very ſpeedily in promoting digeſtion, when this is retarded by a weakneſs of the ſtomach. It muſt, however, be adminiſtered with prudence, for it is known to be dangerous when taken in too great quantities. It is alſo applied externally, with very happy effects, to remove the headach, and cure burnings, &c. Hoffman, who paid much attention to the combinations of alcohol with the ſulphuric acid, made uſe of a medicine conſiſting of ſweet oil of wine, diſſolved in alcohol, which he called his *anodyne mineral liquor.* The Faculty of Medicine of Paris have added æther to this liquor, and have, in their Diſpenſary, directed it to be prepared by mixing two ounces of alcohol, which paſſes before the æther, two ounces of æther, and twelve drops of ſweet oil of wine. This medicine is employed in the ſame way as æther, but is greatly inferior in its effects.

The nitric acid acts upon alcohol with great rapidity. Navier of Chalons is the firſt who has given an eaſy and not very expenſive proceſs for the preparation of nitric æther. His proceſs is as follows:—Into a very

ſtrong bottle of the manufactory of Sèves, pour twelve ounces of very pure and highly rectified alcohol, and immerſe it in cold water, or rather in pounded ice: at ſeveral different times, ſtirring the mixture each time, add eight ounces of concentrated nitric acid: then cloſe up the bottle with a good cork, covered with leather. Set this mixture aſide, in ſome private place, to avoid accidents from the burſting of the bottle,—which ſometimes happens. In a few hours, bubbles ariſe from the bottom of the bottle, are collected in drops on the ſurface of the liquor, and form, by degrees, a ſtratum of genuine æther. This phænomenon continues to go on for four, or from four to ſix days. As ſoon as the motion of the liquor appears to have ceaſed, the cork muſt be pierced with a pin, in order to the emiſſion of a certain quantity of gas, which would otherwiſe force its way out by uncorking the bottle, and carry with it all the æther. When this gas is diſcharged, the bottle may be unſtopped, the liquor contained in it poured into a funnel, ſtopping the under end of the funnel with the finger, and the ſupernatant æther ſeparated from the reſidue, and received into a glaſs phial.

Mr Woulfe has given a different proceſs for the preparation of nitrous æther. He uſes very large veſſels, which afford room for the reception of the air that is diſengaged. Taking a balloon of clear glaſs, ſufficiently capacious to hold eight or ten pints, and terminating in a neck ſeven or eight feet long, he places it on a tripod, high enough to receive under it a chafing-diſh. The neck of the matraſs is to be adjuſted to a tubulated capital, with a glaſs tube ſeven or eight feet long, adapted to its beak. The lower extremity of the tube is received

into a balloon with two necks, the lower part of which is drawn out into a tube, and inserted into a bottle. The other neck of this balloon joins the bottles composing Woulfe's apparatus, which we have already repeatedly described. When all these vessels are sufficiently luted together, a pound of rectified alcohol, and as much fuming nitrous acid, is to be poured into the matrass, through the hole perforated in the capital: this hole must then be stopped with a crystal stopper, wrapped in a piece of leather. The mixture becomes immediately exceedingly hot: vapours are disengaged, and pass rapidly along the neck of the balloon; and this vessel being exposed to a heat sufficient to boil the liquor which it contains, a quantity of nitric æther passes into the balloon employed as a receiver. This process, though very ingenious, is attended with several inconvenient circumstances: It takes a long time to set up the apparatus which is both very expensive and very troublesome: and it still exposes the operator to danger; for notwithstanding the room afforded in the vessels for the reception of the vapours, yet, so rapidly are they disengaged, that the vessels happen to be pretty often burst, with considerable noise.

M. Bogues, in the year 1773, published another process for preparing nitric æther. He directs to mix, in a glass retort, capable of containing eight pints, a pound of alcohol with a pound of nitric acid, weakened so as to exhibit only twenty-four degrees of M. Baumé's hydrometer;—to adapt to the retort a balloon of the capacity of twelve pints;—to afford a passage to the air, by inserting, at the juncture of the lute, the barrels of two quills;—and to distil the mixture by a very mode-

rate

rate heat, taking care that the retort ſink but a little way in the ſand-bath. By this means he obtained ſix ounces of nitric æther, of ſufficient purity. It appears, from what the Abbé Rozier has ſaid, that Mitouard followed, ſince the year 1770, a proceſs nearly ſimilar to that communicated to the public by M. Bogues. That chemiſt ſubjected four ounces of fuming ſpirit of nitre, with twelve ounces of alcohol, to diſtillation in a retort: He placed the retort gently on the ſand-bath; and by this means, which appeared to him ſimpler than any other that had been recommended, he obtained a quantity of nitric æther, of the ſame kind with M. Navier's. Laſtly, M. de la Planche, apothecary at Paris, has contrived two different ways of preparing nitric æther, each of which has its conveniences. The firſt conſiſts in putting nitre into a tubulated ſtone retort, with a large balloon, and pouring in by the aperture, firſt, concentrated ſulphuric acid, and afterwards alcohol. The ſulphuric acid diſengages ſpirit of nitre, which re-acts upon the alcohol, and forms, almoſt inſtantaneouſly, nitric æther. As æther prepared in this way might be ſuſpected to be partly ſulphuric, he afterwards adopted, in preference to this method, a new proceſs; which is indeed exceedingly ingenious: To a tubulated glaſs-retort, into which he had put ſix pounds of dry nitre, he joined an adapter, and a receiver, communicating by a curved tube with an empty bottle. The bottle, again, by means of a ſyphon, communicated with another bottle, containing three pounds of the beſt alcohol. Then, after properly luting the whole of this apparatus, and placing the retort on a cinder-bath, he poured upon the nitre, through the aperture in the retort, three pounds of concentrated

sulphuric acid,—shut up the retort with a crystal stopper, urged it with fire, till it was raised to ebullition,—and maintained it in that state, till it ceased to emit vapours. On this occasion, the sulphuric acid disengages the acid of nitre, one part of which passes into the receiver, and the rest into the second flask. At the end of the operation, the receiver contains fuming nitrous acid, the retort sulphate of potash, and the second bottle an æthereal liquor. This æthereal liquor is next distilled in a retort, with a single balloon, and only two thirds of the product taken up. This product is distilled with a fifth part of fuming nitrous acid, gradually poured upon it, through a long glass funnel: of this likewise no more than two thirds are distilled off. Lastly, This second product is rectified on potash; four ounces are, at the first, taken off; and then the remaining three fourths. The four ounces are very pure nitric æther; and the remaining three fourths a nitrous, anodyne mineral liquor. The residues of these two rectifications are dulcified spirit of nitre.

The nitric æther obtained by these processes is a yellowish fluid, equally volatile and susceptible of evaporation with sulphuric æther. Its smell is nearly the same with that of sulphuric æther, but rather stronger, and not so pleasant. Its taste is hot, and more disagreeable than that of sulphuric æther. It contains a small quantity of superabundant acid. It causes the corks to start from the phials in which it is inclosed; a large quantity of gas being constantly disengaged from it. It burns with a brighter flame, and a thicker smoke, than sulphuric æther, and does not leave just so large a proportion of carbonaceous residue. Lastly, like sulphuric æther, it

takes

takes up gold from a ſolution of that metal, and becomes charged with a certain quantity of it.

The reſidue of nitric æther is of a lemon-yellow colour; its ſmell is acid and aromatic; its taſte pungent, like that of diſtilled vinegar. According to M. Baumé, it affords, by diſtillation, a clear liquor, the ſmell of which is ſweeter than that of nitric æther, and its taſte an agreeable acid. It reddens ſyrup of violets, combines with water in any proportion, and efferveſces with carbonate of potaſh. There remains in the retort, after this liquor is diſtilled off, an amber-yellow matter, friable, and ſimilar in its appearance to real amber, which attracts moiſture from the atmoſphere, becomes pitchy while it continues expoſed to it, and diſſolves in water without rendering it mucilaginous. This ſubſtance, which M. Baumé calls gummi-ſaponaceous, affords in the retort a few drops of an acidulated liquor, which is very clear, of an oily conſiſtency, and a light empyreumatic ſmell. After the diſtillation, there remains a ſpongy coal, which is brilliant, inſipid, and very obſtinately fixed in the fire. Bucquet ſays, that the liquor which remains after the formation of nitric æther, takes, by evaporation, a mucilaginous conſiſtency; and that, in a longer or a ſhorter ſpace of time, there are ſaline cryſtals formed in it, which bear a conſiderable reſemblance to hairy caterpillars, and are called *cryſtals of Hiærne*, from the name of the chemiſt who gave the firſt deſcription of them. This reſidue has been diſcovered to be oxalic acid; and the radical principle of that acid appears therefore to be contained in alcohol.

The muriatic acid does not act in any perceptible manner on alcohol. This acid is only dulcified by ſimple

mixture with this liquor, as are alſo the two others, when mixed in a ſmall proportion with alcohol. M. Baumé, in his Diſſertation on æther, mentions his having obtained a little muriatic æther, by bringing vapours of muriatic acid into contact with vapours of alcohol.—Ludolf and Pott employed ſublimated muriate of antimony with this view. Baron Bornes directs to diſſolve oxide of zinc in muriatic acid, and to diſtil that ſalt, after concentrating it by evaporation in cloſe veſſels with alcohol. This is an eaſy enough way of obtaining muriatic æther. But no body has paid ſo much attention to this object as the Marquis of Courtanvaux. His proceſs is, to pour into a glaſs-retort a pint of alcohol, with two pounds and a half of muriate of tin, or *fuming liquor of Libavius*. A very ſtrong heat is thus excited; and there ariſes a white ſuffocating vapour, which diſappears when the mixture is ſtirred. An agreeable ſmell then exhales from it, and the liquor takes a lemon-colour. Place the retort on a hot ſand-bath: join to it with luting two balloons; and let the moſt diſtant of the two be immerſed in cold water. The firſt product which paſſes is dephlegmated alcohol; after it the æther aſcends. The aſcent of the æther may be diſtinguiſhed by its ſweet ſmell, and the ſtriæ which it forms on the ſides of the retort. When the ſmell changes, and becomes ſtrong and ſuffocating, the receiver muſt be changed, but the diſtillation ſtill carried on. The product now obtained is firſt a clear acid liquor, with ſome drops of mild oil ſwimming on its ſurface; next, a yellow matter, of the conſiſtency of butter, which is a true muriate of tin; and laſtly, a brown ponderous liquor, which exhales a conſiderable quantity of white vapours.—There

remains

remains in the retort a grey pulverulent matter, an oxide of tin. The æthereal product muſt now be poured into a retort upon a quantity of potaſh: The phænomena which follow are, a lively effervefcence, and a copious precipitation, both owing to the tin which the acid has carried up with it when diſtilled. By adding a little water, and diſtilling the contents of the retort by a moderate heat, a product is obtained, equal to about one half of the former æthereal product. All the liquors which paſs after the muriatic æther are ſtrongly impregnated with oxide of tin: They attract moiſture from the atmoſphere, and combine with water, without affording any precipitate. It was not known to what cauſe the rapidity with which the muriatic acid contained in the fuming liquor acts upon alcohol, while the pure acid does not act upon it at all, ſhould be aſcribed: but from a diſcovery of Scheele's, it appears that it is owing to the acid being then in the ſtate of oxigenated muriatic acid, in conſequence of which the exceſs of oxigene which it contains converts the alcohol into æther. This theory was firſt advanced by myſelf, in the year 1781; and has been ſince confirmed by the experiments of Meſſrs Berthollet and Pelletier.

M. de la Planche, apothecary, has propoſed the preparing of muriatic æther, by pouring into a tubulated retort ſulphuric acid and alcohol upon decrepitated muriate of ſoda. The muriatic acid gas, diſengaged by the ſulphuric acid, upon entering the receiver, comes into contact with the alcohol in a vaporous ſtate, and combines with it. The reſult of the combination is, an æthereal acid, which, by rectification on fixed potaſh, becomes pure æther. It appears, that in this proceſs the

muriatic acid deprives the ſulphuric acid of a part of its oxigene.

Muriatic æther is highly tranſparent and volatile. It has nearly the ſame ſmell with ſulphuric æther. It burns in the ſame way, and affords a ſimilar ſmoke. It differs from it, however, in two properties: Muriatic æther exhales, as it burns, an odour equally pungent and lively with that of the ſulphureous acid; and it has a ſtiptic taſte, like alum. Theſe two phænomena indicate this æther to be of a different nature, and poſſibly leſs perfect than the two preceding ſorts of æther. No doubt, when its properties are more minutely examined, it may be found diſtinguiſhed by other more remarkable peculiarities.

After this account of the manner in which theſe three mineral acids act upon alcohol, we are to proceed with the hiſtory of this fluid. Little attention has been paid to the action of the other acids on alcohol. We know only, that it combines readily with the boracic acid; that in conſequence of combination with this acid, it burns with a green flame; and that alcohol abſorbs a quantity of carbonic acid gas, more than equal to its own bulk. As to the neutral ſalts, Macquer has aſcertained, that this ſpirit diſſolves ſulphuric neutral ſalts, but with great difficulty; that nitric and muriatic ſalts combine with it much more readily; and that the leſs intimately the acid is combined with the other principle of theſe ſubſtances, the more of them does the ſpirit uſually diſſolve. Alcohol, boiled on ſulphate of potaſh and ſoda, diſſolved none of either of theſe neutral ſalts. Neither does carbonate of potaſh, or of ſoda, unite with it: Moſt ammoniacal ſalts combine with it.

Deliquefcent earthy falts, fuch as calcareous and magnefian nitrate and muriate, diffolve very readily in it. Some metallic falts are alfo very foluble in alcohol; fuch as, fulphate of iron in mother-water, nitrate of copper, muriate of iron and of copper, oxigenated muriate of mercury, or corrofive fublimate. All cupreous falts caufe alcohol to burn with a beautiful green flame. M. de Morveau has fince given a fuller table of the different degrees in which falts are foluble by alcohol, which is inferted in the *Journal de Phyfique*.

Alcohol does not diffolve fulphur, either in maffes or in a powder; but thefe two bodies unite, if brought into contact when they are both in a vaporous ftate, as has been difcovered by the Count de Lauraguais. His procefs confifts in putting fulphur in powder into a glafs-cucurbite, putting into the fame veffel, above the flowers of fulphur, a bottle filled with alcohol, and heating the cucurbite on a fand-bath, with a capital and a receiver adapted to it. Both the fulphur and the alcohol are volatilized at the fame time: They combine, and pafs into the receiver, in a fluid which is fomewhat turbid, and diffufes a fœtid fmell. It contains about a grain of fulphur to the drachm of alcohol. I have difcovered that the fame combination may be produced by diftilling fulphureous waters, fuch as the water of Enghien, with alcohol.

Ardent fpirit, or alcohol, does not act at all on either metallic matters, or their oxides. It diffolves amber in part. It produces no effects on black carbonaceous bitumens. It is obferved, that it combines beft with amber, after being diftilled on fixed alkali, and that fixed alkali, mixed with this bituminous fubftance, renders it

much more ſoluble, by reducing it, no doubt, to a ſaponacc ous ſtate.

There are few vegetable matters on which alcohol does not act with more or leſs energy. It deſtroys the colouring part, and frequently the whole ſubſtance of extracts, when they are of an extracto-reſinous, or a reſino-extractive nature: the ſaccharine and ſaponaceous extracts combine with this fluid. Margraff has obtained, by alcohol, a ſaccharine eſſential ſalt from red beet, ſkirret, parſnip, &c. But the matters with which it combines the eaſieſt are volatile oils, the aroma, camphor, balſams, and reſins. Alcohol impregnated with the aroma of plants, is improperly called *diſtilled ſpirituous waters*. To obtain theſe fluids, diſtil alcohol on a balneum-mariæ with odorous plants. The liquid takes up the odorous principle, and is volatilized with it, carrying off, at the ſame time, a certain quantity of volatile oil, which cauſes it to become white with diſtilled water: But the oleaginous principle may be ſeparated, by rectifying it on a water-bath by a very moderate heat; and care muſt be taken, that no more than three fourths of the alcohol employed be drawn off, leſt ſome other ſubſtance beſides the aroma ſhould be volatilized with it. The ſmell of theſe diſtilled ſpirituous waters becomes more and more agreeable as they grow older; and it appears, that the odorous principle combines more intimately with the alcohol the longer they are in union.

So great is the affinity between the aroma and alcohol, that alcohol detaches it from volatile oils and water.—When alcohol is diſtilled on volatile oils, and on water impregnated with the odorous principle of a plant, the

alcohol

alcohol ſeizes the odorous principle, leaving the oil and the water deſtitute of ſmell. It is obſerved, that alcohol diſſolves thick and ponderous volatile oils, more readily than ſuch as are very light and fluid. Water ſeparates the principles of this compound: It precipitates the oil in the form of opaque white globules; but the aroma ſtill remains combined with the alcohol. This liquid eaſily diſſolves camphor in a cold ſtate; but it diſſolves ſtill a greater quantity of it when aſſiſted by the action of heat. This ſolution, in the proportion of two drachms of camphor to the ounce of alcohol, with water added, drop by drop, affords a cryſtalline vegetative figure, which has been obſerved by M. Romieu: It is a perpendicular filament, with needles riſing upon it, under an angle of ſixty degrees. This experiment ſucceeds but ſeldom; as it is ſo very difficult to employ preciſely the proper quantity of water, the proper degree of cooling, &c.

Compounds of oily or reſinous juices with alcohol, in which the alcohol is ſo ſtrongly charged with the oleaginous or reſinous juice, as to be coloured by it, and to afford a copious precipitate in water, are called *tinctures*, *elixirs*, *balſams*, *quinteſſences*, &c. Like diſtilled ſpirituous waters, theſe are either ſimple, as when there is only one matter diſſolved in them; or compound, when they contain ſeveral matters together. Theſe medicines are generally prepared by expoſing the juice in powder, or the dry plant, the volatile oil or reſin of which is to be diſſolved, to the action of alcohol, aſſiſted by ſtirring, and by the gentle heat of the ſun or a ſand-bath. To extract the reſins, or any other vegetable matters, from ſeveral different plants at once, care muſt be taken, firſt

to digeſt the matter which is the leaſt liable to be affected by the action of the alcohol, and then to expoſe to it, ſucceſſively, the other ſubſtances over which it has greater power. When the menſtruum is charged with as much of theſe matters as it can receive, it is ſtrained off. Sometimes a compound tincture is prepared at once, by mixing together ſeveral ſimple tinctures. In this manner, the *elixir proprietatis* is prepared, by mixing the tinctures of myrrh, ſaffron, and aloes. Reſins and balſams may be ſeparated from alcohol by pouring water upon the tinctures, or diſtilling them; but in either of theſe caſes, the alcohol retains the odorate principle. Water is not capable of decompoſing tinctures formed with extracto-reſinous, or reſino-extractive matters, ſuch as thoſe of rhubarb, ſaffron, opium, gum-ammoniac, &c.; for theſe matters are equally ſoluble in both the menſtrua.

Alcohol and brandy are very generally uſed, and applied to a great variety of purpoſes. The laſt of theſe liquors is drunk as a cordial, to revive the exhauſted ſpirits; but in exceſs it is dangerous, for it dries up the fibres, and occaſions ſhaking, palſy, and dropſy. Alcohol, either pure or mixed with camphor, is uſed to ſtop, by external application, the progreſs of gangrenes.

Diſtilled ſpirituous waters are adminiſtered in medicine, as tonics, cordials, antiſpaſmodics, ſtomachics, &c. They are given either diluted in water, or ſweetened with ſyrups.

Of theſe waters with ſugars, there are certain drinks prepared, which are known under the name of *ratafias*, or *liqueurs*. Theſe drinks, when properly prepared, and taken in ſmall quantities, may be of ſervice; but they

commonly

commonly agree with very few people, and are hurtful to very many. Theſe liquors, taken in exceſs, are extremely dangerous to the human conſtitution. Inſtead of invigorating with new ſtrength, and fortifying the tone of the ſtomach, as they are commonly thought to do, they produce moſt frequently a quite contrary effect. Thoſe which, drunk but ſeldom, and with great moderation, are the leaſt injurious, are prepared cold, with one part of alcohol diſtilled upon the aromatic ſubſtance which is to afford the flavour, two parts of water, and one of the fineſt ſugar.

Tinctures have nearly the ſame virtues with diſtilled ſpirituous waters, but they act with much more energy; and therefore they are to be uſed in much ſmaller quantities, and given in wine, in potions, and even in aqueous liquors. The precipitate which they yield in the laſt of theſe, is equally ſuſpended through the mixture, and beſides the odorous part remains diſſolved in the alcohol.

Laſtly, Alcohol combined with the copal reſin, with oil of aſpic, or the greater lavender, or with oil of turpentine, forms *varniſhes*, which are called *drying;* becauſe, when a coat of this compound is laid on any body to varniſh it, the alcohol is ſoon volatilized, and leaves on the varniſhed body a tranſparent reſinous plating. The volatile oils, which are mixed with this compoſition, hinder the varniſh from drying too haſtily, and, by communicating to it ſomewhat of an unctuous nature, render it leſs brittle than it would otherwiſe be.

CHAP. XXIV.

Of Acetous Fermentation, and of the Acetous and the Acetic Acids.

MANY vegetable ſubſtances are ſuſceptible of acetous fermentation. Of this kind are gums, and amylaceous fæcula diſſolved in boiling water; but ſpirituous and fermented liquors poſſeſs this property in the moſt eminent degree. Acid fermentation may be excited in any of theſe fluids, by expoſing them to the action of heat and air at the ſame time, ſo as to convert them into what is called *vinegar*. This liquor is chiefly prepared from the wine of grapes; but very good vinegar might be alſo prepared from cyder, perry *, &c.

There are three conditions neceſſary to vinous fermentation: 1. A heat of twenty or twenty-five degrees of Reaumur's thermometer, or from 75° to 90° of Fahrenheit's: 2. A ſubſtance at once viſcous and acid, ſuch as mucilage and tartar: 3. The contact of air. The change

* Vinegar is made in Britain from wort, the infuſion of malt.

change which wines undergo, when converted into vinegar, can be attributed to nothing but an inteſtine motion, excited in thoſe bodies in conſequence of their containing a certain quantity of mucilaginous matter, unaltered, and ſtill ſuſceptible of another fermentation. The preſence of an acid matter, ſuch as tartar, is requiſite to produce acid fermentation. Laſtly, The contact of air is indiſpenſibly neceſſary; and it appears,—it has indeed been proved by the Abbé Rozier, that the liquor abſorbs a portion of air while it ferments; this is probably oxigene.

All kinds of wine are equally good for making vinegar. The worſt are preferred, becauſe they are the cheapeſt. But the experiments of Beccher and Cartheuſer ſhew, that generous wines, not deſtitute of ſpirit, afford generally the beſt vinegar.

Boerhaave, in his Elements of Chemiſtry, has given a very good proceſs for the preparation of vinegar. Take two caſks: at ſome diſtance from the bottoms of theſe caſks, form within each of them a falſe bottom of wicker-work: upon this falſe bottom ſpread grape-ſtalks and vine-branches; pour upon theſe wine, till one of the caſks be entirely full, and the other half-full. The fermentation will firſt begin in the latter: when it is fairly commenced, fill up this caſk with wine from the other: by this means, the fermentation is moderated in the full caſk, and begins in the other. After it has continued for a due length of time, fill up the latter caſk again, from the caſk in which the fermentation firſt began:—thus the fermentation is again excited in the former, and becomes languid in the other. The two caſks are to be thus ſucceſſively filled up and emptied, till ſuch

time as the vinegar be entirely formed; which is not, usually, in less than fifteen days.

In observing the phænomena of this fermentation, we perceive a good deal of boiling and hissing:—The liquor becomes hot and turbid; and a great many bubbles and filaments appear to run through it in all directions: there exhales from it a lively acid smell, which is in no way dangerous: it absorbs a great deal of air. There is a necessity for stopping the fermentation every twelve hours: by degrees these phænomena disappear; the heat falls, the emotion ceases, and the liquor becomes clear. It deposites a glareous sediment, in reddish flakes, which stick to the sides of the casks. It appears, from a sufficient number of experiments, that the smaller the quantity of the wine, and the more it is exposed to the contact of air, so much the more readily does it pass into the state of vinegar. Care must be taken to draw off the vinegar clear, when it is thus prepared, in order to separate the lee, which, were this precaution neglected, would cause it to pass into the state of putrid fermentation.—Vinegar does not, like wine, deposite tartar by rest: this salt was dissolved, and combined with the alcohol and water, during the fermentation. It is even probable, that the presence of this salt has a principal influence in calling forth the properties of vinegar from a latent state. This vinegar is of a lighter or an higher colour, according to the nature of the wine from which it is prepared: but even the lightest coloured vinegar is generally much higher coloured than any sort of white wine; because the colouring part of the tartar, which has been called forth from a latent state by the production of the acid, is dissolved in it.

Vinegar

Vinegar prepared in the manner above deſcribed is extremely fluid, of an acid ſpirituous ſmell, and of a taſte in a greater or a leſs degree ſour. It reddens blue vegetable colours. When expoſed to a moderate heat, in veſſels indifferently ſtopped, it is altered, loſes its ſpirituous part, depoſites a great deal of mucilaginous flakes and filaments, and aſſumes a putrid taſte and ſmell. M. Scheele has ſhewn, that it muſt be boiled for a few minutes, in order that it may be preſerved unſpoiled.

When vinegar is diſtilled by naked fire, in a ſtone cucurbite covered with a capital, or in a glaſs retort on a ſand-bath, it affords a phlegm of a lively and agreeable ſmell, ſcarcely acid; to which immediately ſucceeds a very white, and ſtrongly odorous acid liquor: this is diſtilled vinegar: What follows is leſs odorous, but more acid; and the farther the proceſs advances, the more acid does the product become.—Theſe ſeveral products may be taken ſeparately; by which means, ſo many different ſorts of diſtilled vinegar will be obtained, of various degrees of acidity and ſmell. The operator muſt be ſatisfied with obtaining two thirds of the liquor, which forms the pureſt vinegar. The portion which paſſes after this, is more acid; but it has an empyreumatic ſmell, which may be removed by expoſing it to the air. It likewiſe acquires a faint colour. This operation ſhews the acetous acid to be more ponderous than water. The reſidue is thick, and of a dirty, deep-red colour. It depoſites a certain quantity of tartar, and is in an high degree acid.—Evaporated over an open fire, it takes the form of an extract; and if, when dry, it be diſtilled in a retort, it affords an acid reddiſh phlegm, an oil which is at firſt light and coloured, but becomes after-

wards ponderous; with a little ammoniac.—The residual coal, now left, contains a considerable proportion of fixed alkali.

Vinegar may be concentrated by exposing it to frost.—That portion which still remains liquid becomes highly acid, and is decanted off. The frozen part is almost entirely water. Only a very little vinegar is obtained by this operation.

The acid of vinegar, when separated from tartar and from its colouring part by distillation, is susceptible of combination with a great number of bodies.

It combines only in an imperfect manner with aluminous earth, and forms with it needled crystals, the properties of which are but very little known. The name of this salt (in the new Nomenclature) is *Acetite of alumine.*

It combines readily with magnesia, affording in the combination a salt, which is extremely soluble in water, and does not crystallize, but affords, by evaporation, a viscid, deliquescent mass. Acetite of magnesia is decomposable by fire, by mineral acids, by barytes, by lime, and by the three alkalis.—It is very soluble in alcohol.

The acetous acid combines with lime; and decomposes chalk, disengaging its acid in the form of an elastic fluid.—The salt which it forms with lime crystallizes into very fine needled crystals, of a glossy appearance, like satin.—Calcareous acetite is sour and bitter: it effloresces in the air. It is decomposed by fire; by fixed alkalis, which separate the earth; and by mineral acids, which disengage the acid.

The

The combination of the acetous acid with potaſh, is improperly called, in the laboratories, *foliated earth of tartar:* it ſhould be denominated, *acetite of potaſh.* In preparing this ſalt, a quantity of very pure diſtilled vinegar is poured upon carbonate of potaſh, prepared by the incineration of tartar; the mixture is ſtirred, and vinegar is poured in, till the ſalt be fully diſſolved, and the two ſubſtances mutually ſaturated:—there ſhould rather, indeed, be an exceſs of the acid.—This liquor is filtrated, and evaporated by a very moderate fire, in a veſſel of porcelain or pure ſilver. When it becomes thick, the evaporation is continued on a water-bath till it be quite dry. By this means a very white ſalt is obtained.—If expoſed to too much heat, it takes a grey or a brown colour, becauſe a portion of the vinegar is burnt.—Some chemiſts affirm, that acetite of potaſh may be obtained in a regular form, by ſuffering the ſolution to cool after having evaporated it to a thick pellicle.

Acetite of potaſh is of a pungent, acid, urinous taſte.—By the action of fire it is decompoſed, ſo as to afford, in the retort, an acid phlegm, an empyreumatic oil, ammoniac, and a large quantity of ſtrong ſmelling gas, conſiſting of carbonic acid, with hydrogenous gas. The reſidual coal contains a good deal of naked potaſh.—This ſalt ſtrongly attracts the moiſture of the atmoſphere, and is very ſoluble in water. The ſulphuric acid decompoſes it. To effect this decompoſition, one part of concentrated ſulphuric acid is poured on two parts of acetite of potaſh, introduced into a tubulated glaſs-retort, with a receiver fitted to it. There is inſtantly diſengaged, with a lively effervеſcence, a vaporous fluid,

of a poignant ſmell, which, in the receiver, condenſes into acetic acid, the *radical* principle of *vinegar*. This vinegar is highly concentrated, and ſtrongly acid, but not pure, and always mixed with a certain quantity of ſulphureous acid, which may be diſtinguiſhed by its ſmell.—The tartareous acidulum likewiſe decompoſes acetite of potaſh; becauſe it has a nearer affinity than the acetous acid with the alkaline baſe of this ſalt.

Vinegar enters into a perfect combination with ſoda, and forms with it a ſalt which has been improperly called *cryſtallizable foliated earth*: We give it the denomination of *acetite of ſoda*. The only difference between this ſalt and acetite of potaſh, is, that it cryſtallizes in ſtriated priſms, much like thoſe of ſulphate of ſoda, and does not attract moiſture from the atmoſphere. To obtain it in regular cryſtals, its ſolution muſt be evaporated to a pellicle, and then ſet in a cool place. Acetite of ſoda, like acetite of potaſh, is decompoſable by fire, and by mineral acids. To theſe particulars we may add, that when alkaline acetous ſalts are diſtilled by a ſtrong fire, the reſidues which they leave are ſo many pyrophori, and burn when expoſed to the air. M. Prouſt, to whom we owe theſe diſcoveries, thinks the diviſion of a carbonaceous reſidue, by an earth or a metallic oxide, to be the only condition neceſſary to the production of a pyrophorus.

The acid of vinegar forms, with ammoniac, a liquor that is called *ſpirit of Mendererus*, and is properly ammoniacal acetite. This ſalt is ſo volatile that it cannot be evaporated without a great part of it being loſt; yet, by ſlow evaporation, it may be obtained in needled cryſtals, which are of a hot pungent taſte, and very ſpeedily attract

attract moiſture from the atmoſphere. Ammoniacal acetite is decompoſed by the action of fire; by lime and alkalis, which diſengage the ammoniac; and by mineral acids, which ſeparate the acetous acids.

Vinegar acts upon almoſt all metallic ſubſtances; and exhibits, in its combinations with them, a number of very important phænomena.

It does not appear that this fluid is capable of effecting an immediate ſolution of oxide of arſenic; but this oxide, by diſtillation with equal parts of acetite of potaſh, afforded M. Cadet, and the chemiſts of the Academy of Dijon, a fuming liquor of a very ſtinking ſmell, very tenacious, and of a very ſingular nature. M. Cadet firſt obſerved this liquor to be capable of inflaming fat lute. The academicians of Dijon, wiſhing to examine a yellowiſh matter of an oleaginous conſiſtency, which they found accumulated in the bottom of a bottle containing arſenico-acetous fuming liquor, decanted off a part of the ſupernatant liquor, and poured the reſt on a paper-filter. Only two or three drops had paſſed, when ſuddenly there aroſe a very thick ſmoke, of a nauſeous ſmell, which formed a column extending from the veſſel to the cieling of the room: a ſort of ebullition took place around the edges of the matter, and from it there aroſe a beautiful roſe-coloured flame, which continued to burn for ſeveral ſeconds. A particular account of theſe elegant experiments may be ſeen in the third volume of the *Elements of Chemiſtry* of Dijon. Theſe chemiſts compare the liquor of which we are ſpeaking to a liquid phoſphorus: We take it to be a ſort of pyrophorus, as well as ſome others of which we are hereafter to ſpeak. The reſidue remaining after the diſtillation of

acetite of potash, with oxide of arsenic, consists chiefly of potash.

Vinegar dissolves oxide of cobalt: the solution is of a pale rose-colour.

It acts neither on bismuth, nor on its oxide; but dissolves oxide of manganese.

It accomplishes a direct solution of nickel, according to M. Arwidsson. This solution affords green crystals, of the form of a spatula.

This acid does not act upon antimony; but it appears to dissolve the vitreous oxide of that semi-metal; for Angelus Sala made up an emetic preparation of these two substances.

Both zinc and its oxide dissolve very readily in distilled vinegar. M. Monnet obtained, by evaporating this solution, crystals in the form of broad plates. Acetite of zinc fulminates on the coals, and gives out, on the occasion, a faint bluish flame. It affords, by distillation, an inflammable liquor, a yellowish oily fluid, the colour of which soon changes to a deep green, and a white sublimate, which burns by the light of a taper, with a beautiful blue flame. The residue is in the state of a scarcely combustible pyrophorus.

The acid of vinegar does not dissolve mercury in a metallic state. This combination may, however, be effected by attenuating the mercury into very small particles in the manner of Keyser. Mercury, in the state of oxide, combines easily with vinegar. The only thing necessary to produce this combination, is, to boil the acid upon the red oxide of mercury, called *precipitate per se*, upon *turbith*, or upon mercury, precipitated by potash from a nitric solution of that metal. The liquor becomes

comes white, but regains its tranſparency while boiling. It is filtrated. By cooling it precipitates ſilver-coloured cryſtals, in the form of ſparkling ſcales, reſembling the cryſtals of the boracic acid. This acetite of mercury has obtained the name of *mercurial foliated earth*. It is prepared in an inſtant, by pouring a nitric ſolution of mercury into a ſolution of acetite of potaſh. The nitric acid combines with the fixed alkali of the latter of theſe ſalts, and forms with it nitre, which remains diſſolved in the liquor; and the oxide of mercury, combining with the acid of vinegar, is precipitated in brilliant ſcales. This mixture is filtrated; and the acetite of mercury then remains on the filter. This ſalt is decompoſed by the action of fire. Its reſidue affords a ſort of pyrophorous. It is eaſily altered by combuſtible vapours.

Tin ſuffers but very little alteration from vinegar. This acid diſſolves only a very ſmall portion of the metal. The ſolution afforded M. Monnet, by evaporation, a yellowiſh ſubſtance reſembling gum, and of a fœtid ſmell.

Lead is one of thoſe metals on which the acid of vinegar acts with the moſt powerful energy. It diſſolves this metal with the greateſt facility. Plates of lead, expoſed to the ſteam ariſing from hot vinegar, are covered over with a white duſt, which is called *ceruſe*, and is nothing but oxide of lead, with a little vinegar. This oxide, ground with one-third part of chalk, forms what is uſed in painting under the name of white lead. To ſaturate vinegar with lead, the acid is poured upon *ceruſe* in a matraſs. This mixture is digeſted on a ſand-bath. After remaining in digeſtion for ſeveral hours, the

the liquor is filtered and evaporated to a pellicle. It affords, by cooling and reſt, white cryſtals,—in the ſhape of irregular needles, if the liquor was too much concentrated,—or of flat parallelipipeds, terminating in two ſloping ſurfaces, when the proceſs of evaporation is properly conducted. This acetite of lead is called *ſal* or *ſaccharum Saturni*, on account of its ſaccharine taſte. Its taſte is likewiſe ſtiptic. A ſimilar ſalt is prepared of litharge and vinegar. Equal parts of the two ſubſtances are boiled together till they be mutually ſaturated; and this mixture, after being evaporated to the conſiſtency of clear ſyrup, forms M. Goulard's *extract of Saturn*, which was known long before his time by the name of *vinegar of Saturn*. Acetite of lead is decompoſed by heat. It affords an acid liquor, which is ruddy, and ſtrongly fœtid, but very different from radical vinegar, or the pure acetic acid of which we are ſoon to ſpeak. The reſidue is a very good pyrophorus. This ſalt is decompoſed by diſtilled water, by lime, alkalis, and mineral acids. The *extract of Saturn*, diluted in water, and mixed with a little brandy, forms the *vegeto-mineral* water.

Vinegar diſſolves iron with conſiderable energy. The effervefcence which takes place in this ſolution is owing to the diſengagement of hydrogenous gas from the water which appears to be decompoſed. The liquor aſſumes a red or brown colour. By evaporation, it affords nothing but a gelatinous magma, mixed with a few oblong brown cryſtals. Acetite of iron has a ſtiptic ſweetiſh taſte. It is decompoſed and deprived of its acid by fire. It attracts moiſture from the atmoſphere, and is decompoſed in diſtilled water. When heated till it ceaſes to

exhale

exhale the ſmell of vinegar, it then leaves a yellowiſh oxide, ſubject to the attraction of the loadſtone. The acetous ſolution of iron, affords with nut-gall a very black ink, and might be very advantageouſly employed in dyeing. Alkaline Pruſſiates precipitate from it a very bright Pruſſian blue. Black, yellow, and brown oxide of iron, and native carbonate of iron, or *ſpathoſe iron-ore*, afford with vinegar ſolutions of a very beautiful red colour.

Copper is very eaſily diſſolved in the acetous acid. This ſolution, with the help of heat, takes by degrees a green colour. But the acid acts more readily on this metal, when it has been already oxidated by vinegar, and ſo converted into the ſubſtance called *verdigris*. Verdigris is prepared in the neighbourhood of Montpellier, by laying plates of copper into earthen veſſels, in layers covered with the huſks of grapes, previouſly ſprinkled and fermented with weak vinegar. The ſurfaces of theſe plates are ſoon covered with a green ruſt; which is increaſed by piling them upon each other, and ſprinkling them with weak vinegar. The copper is then ſcraped, and the verdigris put up in leather-bags for ſale. M. Montet, an apothecary at Montpellier, has given a very good deſcription of this proceſs in two Memoirs, printed among the Memoirs of the Academy of Sciences, in the years 1750 and 1753. Verdigris readily diſſolves in vinegar. This ſolution is of a beautiful green colour, and affords, by evaporation and cooling, green cryſtals in truncated quadrangular pyramids, which are called *cryſtals of Venus*. The cryſtals prepared for commerce, which are called *diſtilled verdigris*, on account of their being prepared with

with diſtilled vinegar, are in the form of fine pyramids. Theſe cryſtals take a pyramidal form, from their being depoſited on a piece of wood ſplit into four branches, which are kept ſeparate by a piece of cork.

Acetite of copper has a very ſtrong taſte, and is a violent poiſon, It is decompoſed by the action of fire. It effervеſces in the air, and is covered over with a duſt, the colour of which is a much paler green than the colour of the original ſalt. It is entirely diſſolved in water, but not decompoſed. Lime-water and alkalis precipitate this ſolution.

When this ſalt is reduced to powder, and diſtilled in a glaſs or earthen retort, with a receiver, it affords a fluid, which is at firſt white and ſomewhat acid, but ſoon becomes ſo ſtrong as to be not inferior in acidity to concentrated mineral acids. The receiver is changed, in order that the phlegm and the acid may be obtained ſeparate. The acid has been called *radical vinegar*, or *vinegar of Venus.* It is of a green colour, which it owes to a certain quantity of calx of copper that is carried up with it in the diſtillation. When the diſtillation ceaſes, and the retort is red-hot, the reſidue remaining is a brown copper-coloured duſt, which frequently communicates a metallic tinge to the ſides of the veſſel. This reſidue, as has been obſerved by the Duke d'Ayen, and M. Prouſt, is ſtrongly pyrophoric. *Vinegar of Venus* is rectified by diſtillation with a moderate heat. It is then perfectly white, provided it be not too much urged with fire towards the end of the operation, ſo as to reduce the oxide of copper, remaining in the retort, to too dry a ſtate. The reduction of copper

which may be obferved in this operation, contributes to explain the nature of *radical vinegar*. This acid appears to bear the fame relation to common vinegar which the oxigenated muriatic acid bears to the pure muriatic acid;—or rather, the fame which the fulphuric bears to the fulphureous acid, or the nitric to the nitrous acid. In this operation, the acetous acid combines with the oxigene of the oxide of copper, which paffes at the fame time into a metallic ftate. The effects, in the production of which *radical vinegar* differs effentially from common vinegar, feem to be owing to the oxigene which that acid acquires. For this reafon, we give it, according to the rules of the Nomenclature now adopted through this work, the name of the *acetic acid*.

The acetic acid, or radical vinegar, rectified in this manner, is of fo lively and pungent a fmell, that it can fcarce be borne. Such is its caufticity, that when applied to the fkin it corrodes and cauterizes it: it is extremely volatile and inflammable: when heated in contact with air, it takes fire, and burns with more or lefs rapidity, according as it is more or lefs rectified. This fact has led chemifts to think, that vinegar contains alcohol, and is a fort of natural æther. The poignant agreeable fmell which the firft portions of this acid diffufe, favours the fame opinion.

Acetic acid evaporates all away in the air. It combines with water, with a confiderable heat: with earths, alkalis, and minerals, it forms falts different from thofe into which common vinegar enters; we call them *acetates* of potafh, foda, zinc, mercury, &c. M. de Laffone has fhewn, that the ammoniacal falt formed by radical

vinegar, or the acetic acid, is not of the fame nature with ammoniacal acetite, or fpirit of Mendererus. Although we are not yet fufficiently acquainted with all thefe acetates; yet their form, tafte, and folubility, fhew plainly, that they are of a different nature from acetites.

The Marquis de Courtanvaux has fhown, that nothing but the laft portion of the acetic acid, obtained by the diftillation of acetite of copper or *verdigris*, is fufceptible of inflammation, and that it poffeffes likewife the property of being liable to congelation by cold. This laft portion, rectified, cryftallized in the receiver, in large plates, and in needles; nor did it become fluid, till it was expofed to a heat thirteen or fourteen degrees above the freezing point. In this property, this fubftance refembles oxigenated muriatic acid.

The acetic acid decompofes alcohol, and forms æther, as readily as mineral acids, as has been difcovered by the Count de Lauraguais. All that is neceffary to produce this effect, is to pour a quantity of radical vinegar upon an equal quantity of alcohol. A confiderable heat is excited. The retort is placed upon a hot fand-bath; and two receivers are adapted to it, the moft diftant of which is immerfed in cold water or pounded ice. This mixture muft be quickly boiled. There arifes from it, firft, a dephlegmated alcohol; after that, æther; and then an acid, which becomes gradually ftronger, as the procefs advances. In the retort there remains a brown mafs, much like a refin. Care muft be taken to change the receiver as foon as the fmell of the æther becomes acrid and pungent, and to collect the acid by itfelf. The acetic æther, thus obtained, muft be rectified by a

moderate

moderate heat with potash. In this operation there is a good deal of it lost. The formation of this æther is owing to radical vinegar's containing an excess of oxigene. Scheele relates, that he never succeeded in preparing acetic æther from radical vinegar combined with alcohol, and could not accomplish this preparation without adding a mineral acid. M. Pærner had already made the same remark on the difficulty of obtaining acetic æther by M. de Lauraguais's process. A great many French chemists have, however, employed this process, and I myself, among others, with sufficient success.

M. de La Planche, apothecary, prepares acetic æther by pouring concentrated sulphuric acid and alcohol upon acetite of lead introduced into a retort. The theory and practice of this operation differ in no respect from those of the analogous process by which nitric and muriatic æther are prepared. Acetic æther has, like every other sort of æther, an agreeable smell, which, however, is always mixed with the smell of vinegar, though not acid. It is very volatile and inflammable, burns with a lively flame, and leaves, after its combustion, a carbonaceous mark.

Chemists need to make yet many more researches into the nature of the acetic acid. What we have here said concerning its properties, will serve to shew, 1. That it differs in a singular manner from the acetous acid, or common vinegar. 2. That the difference is owing to the acetic acid's containing more oxigene than the acetous; which excess it has derived from the oxide of copper.— Let us now resume the examination of the other properties of common vinegar.

The acetous acid, with the help of heat, diſſolves the gold precipitated by fixed alkali, from the oxigenated muriatic acid. This acetous ſolution of gold, precipitated by ammoniac, affords *fulminating gold*, as has been ſhown by Bergman. It acts in the ſame way on platina and ſilver. While theſe metals are in a matallic ſtate, vinegar is incapable of acting upon them; but it diſſolves them, when expoſed to it in the ſtate of oxides.

Vinegar is capable of combining with many of the immediate principles of vegetables: It diſſolves extracts, mucilages, and eſſential ſalts It combines with the aroma: It is thought to be the proper ſolvent for gum reſins. It has even, at length, or by the way of diſtillation, a diſcernible influence on fat oils, and reduces them to a ſort of ſaponaceous ſtate. The combinations of vinegar with vegetable ſubſtances have not been farther examined with any accuracy.

This acid is uſed in the extraction of ſeveral of the principles of vegetables, eſpecially in the extraction of their odoriferous principle; and various ſorts of vinegar, both ſimple and compound, are prepared for medical uſes. Vinegar of ſquills, colchicum, &c. afford inſtances of the ſimple; theriacal vinegar, and the vinegar of the four thieves, are compounds. Theſe medicines are prepared by maceration and digeſtion, continued for ſeveral days. As this acid is volatile, it is diſtilled on aromatic plants, whoſe odoriferous principle it takes up. Of this kind is the diſtilled vinegar of lavender, which is uſed at the toilet. Theſe liquors are, in general, not ſo agreeable as ſpirituous diſtilled waters.

Vinegar is very much uſed as an article of ſeaſoning. It is much uſed in medicine, as being cooling and anti-

ſeptic

septic: There is a syrup made up of sugar and vinegar, which is administered with success in burning and putrid fevers, &c. This acid, applied externally, is astringent and resolvent. All its combinations are, in like manner, used as excellent medicines.

Acetite of potash, and acetite of soda, which are known by the names of *terra foliata tartari*, and *acetous mineral salt*, are powerfully discussive and aperient: They are given in doses of half a drachm, or even a drachm each.

Spirit of Mendererus, or ammoniacal acetite, given in doses of a few drops, in certain drinks, is aperient, diuretic, cordial, antiseptic, &c. It is often successful in the leucophlegmatia, or swelling of the external parts of the body.

Acetite of mercury, or *terra foliata tartari*, is an excellent anti-venereal: it is the principal ingredient in Keyser's pills.

The *extract of Saturn*, *vinegar of Saturn*, and *vegeto-mineral* water, are applied externally, as deficcatives. They are violently repercussive, and ought therefore to be very cautiously administered, especially when applied to excoriated or ulcerated parts. Boerhaave mentions several young women who were attacked with consumptions, in consequence of the external use of preparations of lead.

Ceruse enters into the composition of deficcative unguents and plasters; and *verdigris* into several collyria and unguents.

The acetic acid, or *radical vinegar*, is given as a very active, irritating, and stimulating medicine. It is held

to the noſtrils of perſons in fainting-fits. In order that it may be the more conveniently made uſe of, a certain quantity of this acid is poured on ſulphate of potaſh in a coarſe powder, and put into a cloſe-ſtopped phial. This medicine is well known in the world, under the name of *ſalt of vinegar*.

Acetic æther has not yet been applied to uſe; and it is not known whether it poſſeſſes any virtues different from thoſe of the other ſorts of æther.

CHAP.

CHAP. XXV.

Of the Putrid Fermentation of Vegetables.

ALL vegetable ſubſtances that have ſuffered tne ſpirituous and the acid fermentation, are ſtill liable to undergo another inteſtine motion, which is called *putrid fermentation*. Stahl and ſeveral other chemiſts think this fermentation to be nothing but a conſequential part of the two other fermentations already deſcribed;—or rather, that the phænomena of all the three ariſe from *one* internal emotion, the tendency of which is to deſtroy the texture of the ſolids, and to alter the nature of the fluids. It is in fact obſervable, that certain vegetable ſubſtances paſs, of themſelves, through three ſucceſſive fermentations. For inſtance, all ſaccharine matters, diluted in a certain quantity of water, and and expoſed to a heat of—from 60 to 80 degrees, afford; firſt wine, then vinegar, and at laſt loſe entirely their character of acidity: they are altered, become putrid, loſe all their volatile principles, and are in the end re-

duced

duced to a dry, insipid, earthy substance. It is to be observed, however, that a great number of vegetable substances are not, in any sensible manner, liable to pass successively through these three sorts of fermentation, in the above-mentioned order. Insipid mucilages and gums dissolved in water pass into an acid, without becoming discernibly spirituous: the glutinous matter again seems to pass, all at once, into a state of putrefaction, without becoming acid. It appears, then, that although in several of the principles of vegetables, these three fermentations follow each other in regular succession, yet many of those principles are susceptible of the two latter species of fermentation, without having previously undergone the former; nay, are even liable to putrefaction, without becoming previously acid. Those of the last mentioned character partake of the nature of animal substances, and accordingly afford ammoniac by the action of fire, and azotic gas by the acid of nitre. It is in consequence of their possessing such characteristics, that these vegeto-animal substances putrefy so readily.

Certain conditions, well worthy of our attention, are requisite, in order that the intestine motion which changes the nature of vegetable matters, and reduced them to their elementary principles, may take place. Humidity, or the presence of water, is one of the most indispensable of these conditions. Dry solid vegetables, such as wood, suffer no alteration while they continue in that state; but if they be moistened, and their fibres separated, an intestine motion then commences. Water appears, therefore, to be one of the causes of putrefaction. nd when we come to examine the animal kingdom, will have occasion to see, that the intestine motion

with

with which putrefaction begins is owing to the decomposition of that liquid. Heat is not less necessary to putrefaction. Cold, or the temperature of ice, is not only adverse to this spontaneous destruction in substances which have not yet begun to suffer from it, but even retards its progress, and, in some measure, reverses it where it has already begun to operate. The degree of heat necessary to putrefaction, is much inferior to what is required for the spirituous and the acid fermentation; for putrefaction takes place at the temperature of 45 degrees; but a more considerable heat is still more favourable; at least, if it be not so violent as to volatilize all the moisture of the putrescent substance, and render it entirely dry. Access of air is another condition, singularly favourable to putrefaction; for vegetable substances are very well preserved *in vacuo*. The contact of air, however, is not so indispensably necessary to putrefaction as the two other conditions already mentioned; for this phænomenon sometimes takes place without its assistance.

The putrefaction of vegetables exhibits peculiar phænomena. Vegetable fluids, when they putrefy, become turbid, lose their colour, and deposite various sediments: bubbles ascend to the surface, and mouldiness gathers over it in the beginning of the alteration. Soft vegetable matters exhibit the same phænomena, on being simply wet. The emotion then produced is at no time so considerable as that which appears in the cases of spirituous and acetous fermentation. The putrefying body does not appear to increase in bulk, nor does its temperature become higher. But the principal phænomenon of putrefaction is, change of smell, with the volatilization

of an urinous, pungent, acrid principle,—in a word, ammoniac. From this circumſtance, putrefaction has been called *alkaline fermentation*, and ammoniac conſidered as its product. The pungent ſmell exhales by degrees, and is ſucceeded by a nauſeous inſipid ſmell, which can ſcarce be deſcribed. The decompoſition has now attained its height: The putrid vegetable maſs is become very ſoft, like a jelly; it ſinks down, and the odorous principle exhaling from it ſuffers a great many ſucceſſive modifications. At laſt it becomes dry, and loſes, by degrees, its diſagreeable ſmell; and what remains is nothing but a blackiſh, and ſeemingly carbonaceous reſidue, known by the name of *humus vegetabilis*, which is found to contain nothing but ſaline and earthy ſubſtances. Such is the order of the phænomena that are ſucceſſively obſerved in the ſpontaneous decompoſition of putrefying vegetables. But this proceſs of decompoſition, when carried ſo far as to reduce the vegetable body to an earthy or ſaline reſidue, is extremely tedious, and, we may even add, has never yet been obſerved by any perſon with ſuitable attention. Chemiſts and naturaliſts have paid ſtill leſs attention to the putrefaction of vegetable, than to that of animal ſubſtances. No philoſopher has hitherto undertaken to obſerve all the phænomena of the putrefaction of vegetables, but many have begun to deſcribe thoſe which attend the putrefaction of animal matters. Here, therefore, it appears proper for us to conclude our hiſtory of the ſpontaneous and natural decompoſition of vegetables with the following obſervations: 1. The little which we have here ſaid concerning it is ſufficient to ſhow, that the putrefaction of vegetables attenuates, volatilizes, and de-

ſtroys

ſtroys all their humours, and reduces them to an earthy ſtate: 2. We have as yet no certain knowledge of the phænomena and the limits of this ſpecies of putrefaction, which is to be carefully diſtinguiſhed from the putrefaction of animal matters: 3. Laſtly, As this fermentation is much more conſpicuous, and has been much more attentively obſerved in the humours and ſolids of animals; the more extenſive detail of particulars which we are to give, in our account of animal ſubſtances, will complete the ſketch which we have here marked out, and conclude the hiſtory of thoſe facts that are known concerning putrefaction.

PART

PART FOURTH.

The Animal Kingdom.

CHAP. I.

Of the Chemical Analysis of Animal Substances in general (1).

IN the analysis of animal substances, we meet with greater difficulties than in any other part of chemistry; and our chemical knowledge of those substances is accordingly in a more imperfect state than any other branch of the science. The ancient chemists were content with distilling them by naked fire; an operation which is at present known to alter and totally destroy the nature of such compound bodies as the solids or fluids of animals. The only parts of animals that have yet

(1) In the second edition of this Work, the animal kingdom began with a brief account of the nature of animals, the distinctions subsisting among them, the methods requisite for marking out those distinctions in Natural History, and the Natural Philosophy of Animals. The mode of arrangement now adopted in these volumes, and the little connection between the natural description of animals, and the chemistry of animal matters, have induced me to remove that part into a fifth volume. A.

yet been subjected to an analysis, are some of the humours of the human body, and the humours of certain quadrupeds.

Many circumstances have concurred to retard the progress of this branch of chemistry. The difficulty and disagreeableness attending researches of this kind; the imperfection of the chemical methods with which, till within these few years, animal matters were always treated, and which constantly produced on them great alterations; the impossibility which was always found of approaching near to a reproduction of any animal matter by synthesis; and, above all, the smallness of the inducements which any but medical chemists could have to engage in such researches; are the principal reasons which have prevented the enlargement of this department of the science of chemistry. But the researches of several moderns, especially of Messrs Rouelle, Macquer, Bucquet, Poulletier de la Salle, Berthollet, Proust, Scheele, and Bergman, have here opened a new tract of discovery, and shew, that the art of healing may derive the most signal advantages from researches of this kind.

The human body, and the bodies of quadrupeds—the principal animals which engage our attention—are composed of fluids and solids. The humours of animals are divided into three classes, according to the purposes for which they serve. The first contains the recrementitial humours, the use of which is to nourish certain organs: the second comprehends excrementitial humours, which are evacuated by certain emunctories, as useless, and even noxious, when retained too long within the body: the third class consists of humours to which the

characteristics of both the two former classes belong, they being partly recrementitial, and partly excrementitial. To the first class belong the blood, the lymph, the jelly or gelatinous part, the fibrous or glutinous part, the fat, the marrow, the matter which supports interior perspiration, and the osseous juice. The second class consists of the fluid which is insensibly transpired by the pores, the sweat, the mucus of the nostrils, the cerumen of the ears, the gummy matter of the eyes, the urine, and the fæces. Those of the third class are, the saliva, the tears, the bile, the pancreatic juice, the gastric and intestinal juices, the milk, and the seminal liquor. We cannot examine all these fluids in the order in which they are here mentioned: 1. Because they are still but very little known; 2. Because it is absolutely necessary that we treat first of such as have been the most completely analysed.

The solids of animals, which form the parenchyma of their different organs, may be divided into three classes. In the first of these classes I rank the soft white parts, such as the laminæ of the cellular tissue, the membranes, the membranous viscera, the aponeuroses, the ligaments, the tendons, and the skin. The soft red parts form a second class, very different from the former; such are, particularly, the muscles, and a part of the organs which contain muscular fibres, as the stomach, the intestines, the bladder, the matrix, &c. Lastly, the third class comprehends the osseous or bony solids.

Animal matters are at present analysed in a very different way from that in which they were analysed a few years since. They are no longer subjected to decomposition by fire; they are now treated by re-agents, particularly

particularly acids, alkalis, alcohol, &c. The different fluids intermingled with each other, or contained in the vesicles of the different parts, are separated by rest, decantation, filtration, or expression. The action of these substances on colouring matters is examined, and the several changes which they are liable to suffer in different temperatures are observed. Animal liquors are carefully evaporated, and the different salts which they contain extracted from them unaltered.

By these methods of analysis, modern chemists have made a number of important discoveries concerning animal substances. Scheele has found them to contain several acids different from those which were before known. M. Berthollet has demonstrated the existence of phosphoric acid, in a naked state, in urine and sweat; and has likewise found, in animal matters, a remarkable quantity of the azotic principle. This last discovery is one of the most important facts which the analysis of animal matters has made known to us. The existence of azote in these substances, especially in their fibrous parts, accounts for the difference between animal and vegetable matters. This body is obtained in the state of elastic fluidity, or in azotic gas, by treating the flesh of the muscles with nitric acid: even without the operation of any external heat, it is disengaged in a pretty large proportion: it passes before the nitrous gas; and when the nitrous gas begins to be disengaged, the operation should be stopped, and the vessels changed.

M. Berthollet explains by this discovery the formation of the ammoniac which animal substances afford, when treated with fire,—the production and disengage-

ment of this salt by putrefaction,—and the relation between these substances and vegetable matters that are liable to putrefaction, and afford ammoniac by distillation. It appears, in fact, that in both these instances, the ammoniac is formed by the combination of hydrogene with azote. I believe I cannot here do better than give, in M. Berthollet's own words, what he has said concerning the nature of animal substances in general, in a Memoir read before the Faculty of Medicine, and inserted in the *Journal de Physique*, vol. 28. page 272.

" Organized bodies are chiefly composed of two sub-
" stances, which are distinguished from each other by
" very eminent peculiar characteristics. Of these sub-
" stances, one class affords acids, when decomposed by
" the action of fire; the other *volatile alkali*: The one
" class forms *ardent spirit* by fermentation; the other
" immediately putrefies, still affording *volatile alkali*:
" The one leaves, when calcined, a coal that burns ea-
" sily; the other is reduced to a coal which burns with
" difficulty: The one, in short, forms the greater part
" of vegetable, the other of animal substances; and
" hence they are distinguished by these two different de-
" nominations.

" M. Bergman, by means of sugar and the *nitrous acid*,
" produced an acid which he called the *saccharine acid*,
" possessing peculiar and remarkable properties. On ap-
" plying to animal substances this analysis by *nitrous acid*,
" I found that they all afforded more or less *saccharine*
" *acid*, which was always accompanied with a peculiar
" oil. I observed that no ammoniacal salt was obtained,
" but a residue remained, which vegetable substances do

" not

" not afford. From these first experiments, I concluded, " in the *Memoirs of the Academy for the year* 1780, that " animal matters contained some substance analogous to " sugar, in combination with an oil which I considered " as peculiar to animal matters. I learned farther from " my experiments, that *volatile alkali* did not exist in " animal substances, but was produced by some com- " bination, effected either by the action of heat, or by " the influence of putrefaction. And lastly, The residue, " concerning which I did not explain my sentiments in " that Memoir, contains an excess of phosphoric acid, " combined with calcareous earth.

" I afterwards examined the action of metallic *calces* " and salts on animal substances, and proved, that the " action to which these owed their causticity was a con- " sequence of the chemical affinities by which metallic " *calces* tended, with more or less force, to revivication; " the *calces* of silver and mercury, which are very easily " reduced, having an high degree of causticity, and " forming very caustic salts. It follows, on applying " the late discoveries of natural philosophers to the theo- " ry which I have given, that it is the air, existing in a " combined state in metallic *calces*, and without its prin- " ciple of elasticity, which tends to unite with some " principle in animal substances; which principle ap- " pears to me to be the oil which they contain. But " the causticity of alkalis cannot be ascribed to the " same cause: it must be owing to some other affini- " ty. In the Memoirs of the Academy for the year " 1782, I have proved that caustic alkali dissolves " animal substances, without dividing their principles. " I have explained the properties of this combination,

and

" and afterwards employed it in uniting animal sub-
" stances with the different metallic *calces*. Several
" combinations, not previously known to chemists, were
" produced: But caustic alkali, treated in the same
" way with vegetable substances, formed no combina-
" tion with them.

" Pursuing my researches, I have at length discovered
" the principles of *volatile alkali.* I have shown *volatile*
" *alkali* to be a combination of detonating *inflammable*
" *gas*, or, more accurately, of the inflammable gas of
" water with *phlogisticated* or *mephitic* air, in such pro-
" portions, that inflammable gas composes one sixth of
" the weight, or two thirds of the bulk of *volatile alkali.*
" I next ascertained in what manner *volatile alkali* may
" be produced by putrefaction, or the action of fire. All
" substances possessing the characteristics of animal sub-
" stances contain *mephitis*, which may be separated
" from them in abundance, by the operation of the
" *nitrous acid.* When those substances are distilled, there-
" fore, their *mephitis* must of necessity either pass into
" some new combination, or be found among their ae-
" riform products. But among these last it is never
" found; as I fully ascertained by detonizing *inflammable*
" *gas*, obtained by this means, in M. Volta's eudiome-
" ter, and comparing it with inflammable gas obtained
" by distillation from charcoal, and with that of vege-
" table substances; and, after the *inflammable gas*, there
" is none other but the *volatile alkali* among the pro-
" ducts obtained by distillation from animal substances,
" into the composition of which the mephitis can possi-
" bly be received. Consequently, whenever *volatile al-*
" *kali* is formed, the *mephitis* of the animal substances

" combines with the *inflammable gas* separated from the " oil, or more probably with that produced by the de- " composition of the water, whose vital air combines " at the same time with charcoal, to form *fixed air*; " in putrefaction, the *inflammable gas* combines with the " *mephitis*; whereas, in the spirituous fermentation, the " same gas combines with a vegetable oil and sugar to " form *spirit of wine*, in which I have discovered and " separated these substances by means of the *dephlogisti-* " *cated marine acid*.

" From these several observations, it follows, that " animal substances are of a much more compound na- " ture than substances purely vegetable. They contain " a matter analogous to sugar, a peculiar oil, phospho- " ric acid combined with calcareous earth, *mephitis*, and " very probably *fixed air*. It is the phosphoric acid " which exists in the coal of animal substances, in com- " bination with a portion of real charcoal, oil, and earth, " that appears to me to occasion the difference observed " between the coals of animal and those of vegetable " substances."

Such is the accuracy and perspicuity with which M. Berthollet explains the nature of animal substances in general. When these distinct facts and fair deductions are compared with the vague notions which before prevailed concerning the difference between animal and vegetable matters, the progress which chemistry has made within these few years, by means of the researches of Swedish and French chemists, cannot but appear astonishing. There is the strongest reason to hope, that farther experiments on animal matters, upon the same

plan which has been marked out and pursued by the most celebrated chemists, from Margraff and Rouelle to the present instant, will supply a great deal of valuable information concerning these substances; their formation, the alterations which they are liable to undergo, and their destruction; and particularly, may be of the most essential service to the science of Medicine. The truth of this assertion will be fully proved, by the account of the discoveries already made, and of their application, which we are to exhibit in the following chapters.

CHAP.

CHAP. II.

Of the Blood.

THE moſt important, the moſt compound, and the moſt impenetrable of the recrementitial humours, is the blood. We treat of it firſt, becauſe the greateſt phyſicians maintain it to be the ſource and centre of all the other animal fluids. Many phyſicians, eſpecially M. Bordeu, have conſidered it as a ſort of fluid fleſh, a compound of all the animal humours: an opinion, which, though highly probable, has not been yet fully demonſtrated.

The blood is a fluid of a beautiful red colour, of a fat, unctuous, and, as it were, a ſaponaceous conſiſtency; of a taſte ſomewhat ſaline, but almoſt inſipid; and contained in the heart, arteries, and veins. This fluid is differently modified by the different parts through which it flows: For inſtance, in the arteries and veins, in the breaſt, and the region of the liver, in the muſcles and the glands, &c. it is not the ſame. This fact has not ſufficiently engaged the attention of th

In considering the blood as it exists through the whole animal kingdom, we observe, that in different animals it is singularly diversified in colour, consistency, smell, and especially temperature. The last is the most important of all these properties, and seems to depend on the circulation and the respiration. The human blood, and that of quadrupeds and birds, is hotter than the medium which they inhabit; and, for this reason, these are called *hot-blooded animals*. The blood of fishes and reptiles, again, is nearly of the same temperature with the medium which they inhabit; and these are, for this reason, called *cold-blooded animals*. Other properties of this fluid, especially its chemical qualities or characteristics, would probably be found, if we were acquainted with the blood of all animals, to be subject to the same variations.

The human blood, which more especially engages our attention, is differently modified by the age, the sex, the temperament, and the state of the health, of each individual. In infants, the female sex, and phlegmatic persons, it is paler and thinner. In robust and healthy persons, it is thick, of a deep red colour, almost black, and of a much more saline taste than in the former.

Before proceeding to an analysis of the blood, it is necessary that we get acquainted with its physical properties—its colour, heat, taste, smell, and peculiar consistency—of which we have already taken notice. By the microscope we discover in it a great many globules, which, according to Lieuwenhoek and Boerhaave, when broken in circulating through the smaller passages, lose their red colour, and become first yellow, and then white; so that, according to the physician of Leyden,

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a red globule is an aſſemblage of other ſmaller white globules, and owes its colour to its aggregation. There is another ſingular property belonging to the blood. While hot and in motion, it continues fluid and red: When cooled and at reſt, it becomes a ſolid maſs, which, by degrees, ſeparates into two parts; the one red and ſupernatant, its colour dark, and its conſiſtency concrete, till ſuch time as it ſuffer an alteration;—this is called the *clot of the blood:* the other occupies the bottom of the veſſel, and is of a greeniſh yellow colour, and adheſive;—it is called the ſerum or lymph. This ſpontaneous coagulation and ſeparation of the two parts of the blood takes place in the laſt moments of an animal's life; and produces thoſe concrete matters which are found in the heart, and the larger veſſels of deceaſed animals, and have been miſtaken for polypi.

Blood, expoſed to a gentle and continued heat, paſſes into the ſtate of putrid fermentation. When diſtilled on a water-bath, it affords a phlegm of a faint ſmell, which is neither acid nor alkaline, but eaſily putrefies, in conſequence of its containing an animal ſubſtance diſſolved through it. Expoſed to a more intenſe heat, blood, as has been diſcovered by De Haen, gradually coagulates and becomes dry: it then loſes ſeven-eighths of its weight, and becomes capable of effervescence with acids. By conducting the fire properly, it may be hardened into a ſort of corneous ſubſtance. Deſiccated blood, expoſed to the open air, attracts from it ſome degree of moiſture, and, in the courſe of a few months, there is formed on it a ſaline efflorescence, which Rouelle has determined to be carbonate of ſoda. When diſtilled by naked fire, it affords a ſaline phlegm,—that is, a

phlegm holding in ſolution an ammoniacal ſalt, ſuperſaturated with ammoniac. The nature of the empyreumatic acid contained in this ammoniacal ſalt, which was firſt obſerved by Wieuſſens, and has given riſe to ſo many diſputes among phyſiologiſts, has never yet been ſufficiently examined. After this phlegm, a light oil paſſes, —then a ponderous coloured oil, and ammoniacal carbonate contaminated with a thick oil. There remains in the retort a ſpungy coal, very difficult to be incinerated, which is found to contain muriate of ſoda, carbonate of ſoda, oxide of iron, and a matter apparently earthy, which ſeems to be calcareous phoſphate.

Blood, when burnt in a crucible, affords ſeveral products, in the following order. 1. Water and a little ammoniac: 2. Oil and carbonate of ammoniac, which forms a yellowiſh vapour, thicker than the former: 3. Pruſſic acid, which is eaſily diſtinguiſhed by its fœtid ſmell of peach-flowers: 4. Phoſphoric acid, which is formed by the combuſtion of phoſphorus, and is not diſengaged till the blood be reduced to a coal: 5. Carbonate of ſoda, which is volatilized at an intenſe heat: 6. After this there remains in the crucible only a blackiſh, granulated, cryſtallized oxide of iron, mixed with calcareous phoſphate.

Blood combined with alkalis, without previous decompoſition, becomes more fluid by ſtanding. Acids inſtantaneouſly coagulate it, and alter its colour. By filtrating this ſubſtance, evaporating the liquor paſſed through the filter, drying it before a moderate fire, and lixiviating the matter that has been dried, neutral ſalts are obtained, conſiſting of ſoda, with the acid that was mixed with the blood. Alcohol coagulates blood.

If entire blood, mixed with a fourth part of its weight of water, be coagulated by heat, and if a part of the fluid that swims above the coagulated portion be evaporated, a substance of a brown yellow is obtained, which is easily distinguished to be true bile. This discovery, which was made in 1790, confirms the opinion of the ancients; who considered bile as a constituent part of blood.

Experiments made on blood in its original state, do not discover the nature of the substances of which it consists. But the spontaneous decomposition of blood, and the separation of its two component parts, the clot and the serum, afford us an opportunity of acquiring that knowledge by examining each of these matters by itself. Till within these few years, the chemical analysis of the blood was confined to what has been related in the foregoing pages; but Messrs Menghini, Rouelle the younger, and Bucquet, have examined this fluid in a very different manner. The two last of these chemists especially have conducted their experiments on this matter in a way which shews to what perfection the analysis of animal matters may be carried, by proceeding on their plan. The following account of the properties of the several substances which compose the blood, is derived from the discoveries of those philosophers, and from those which I have made myself.

The serum is very far from being pure water, but a peculiar matter, highly worthy of examination, to which we give the name of the *albuminous fluid.* It is of a yellowish white colour, somewhat inclining to green; its taste is saltish, but nearly insipid; its consistency unctuous and adhesive. When exposed to the action of fire, it coagulates and becomes hard, long before it can be

 heated

heated to ebullition: it communicates a green tinge to ſyrup of violets. By diſtillation on a water-bath, it affords a phlegm of a mild inſipid taſte, which is neither acid nor alkaline, but ſpeedily putrefies. After loſing this phlegm, it is dry, hard, and tranſparent like horn: it is no longer ſoluble in water: by diſtillation in a retort, it affords an alkaline phlegm, a conſiderable quantity of ammoniacal carbonate, and a very fœtid thick oil. All theſe products, in general, have a peculiar fœtid ſmell. The coal of the ſerum, when diſtilled by naked fire, almoſt entirely fills the retort. It is ſo difficult to incinerate, that it muſt be kept burning for ſeveral hours, and expoſed to a great deal of freſh air, before it can be reduced to aſhes. The aſhes are of a blackiſh grey colour, and contain muriate and carbonate of ſoda, with calcareous phoſphate.

The ſerum, if expoſed for ſome time to an hot temperature, in an open veſſel, paſſes readily into a ſtate of putrefaction, and then affords a conſiderable quantity of ammoniacal carbonate, with an oil, the ſmell of which is inſufferably nauſeous. It putrefies ſo ſpeedily, that Bucquet could not diſcover whether it paſſed into an acid ſtate before becoming alkaline. This liquor combines with water in any proportion; and then it loſes its conſiſtency, its taſte, and its greeniſh colour. To promote the combination, the mixture needs to be ſhaken; becauſe the difference between the denſities of the two fluids obſtructs their union. The ſerum, when poured into boiling water, coagulates, almoſt wholly, inſtantaneouſly. A portion of this fluid forms, with the water, a ſort of opaque and milky white liquor; which, according to Bucquet, poſſeſſes all the characteriſtic properties

of milk; that is, is rarefied, and caused to mount up, like that fluid, by heat, and is coagulated by the same agents—by acids, and by alcohol.

The serum or albuminous fluid possesses the property of fixing and rendering solid by heat, two or three times its weight of water. When seven or eight parts of water are added to one of serum, then the albumen is not coagulated by heat. The cause of this singular property, of coagulating by heat, which the serum of the blood possesses, has hitherto eluded the researches of philosophers. I imagine it to be owing to the combination of oxigene, assisted by heat, as it is in all other substances; since a metallic oxide mixed with serum thickens it, whilst itself passes into a metallic state. Besides, all the facts relative to the coagulation of the albuminous matter prove, that the more air this substance contains, the more of it it has absorbed, and the more speedily it coagulates by fire, so much the more solid does it become by this agent.

Alkalis render the serum more fluid by effecting a sort of solution of it. Acids alter it in a different manner, increasing its consistency, and coagulating it. This mixture, filtrated, and evaporated after filtration, affords a neutral salt formed of soda and the acid employed: And this fact proves soda to exist in the serum in a naked state, in full possession of all its properties. The coagulum formed in this liquor by the addition of an acid, is very speedily dissolved in ammoniac, which is the genuine solvent of the albuminous part of the blood; but it does not dissolve at all in pure water. Acids precipitate this matter in union with ammoniac. The coagulum, distilled by naked fire, affords the same products as the

the ſerum deſiccated; and its carbonaceous reſidue contains a good deal of carbonate of ſoda;—a circumſtance which, in Bucquet's opinion, ſhews, that there exiſts a portion of this ſalt in a ſtate of intimatec ombination, in the ſerum, which the acid employed to coagulate it does not ſaturate.

The ſerum, inſpiſſated, affords azotic gas by the action of the nitric acid, with the help of a moderate heat. On increaſing the fire, there is a quantity of nitrous gas diſengaged from the mixture: the reſidue affords oxalic acid, and even a ſmall quantity of malic acid.

The formation and diſengagement of the Pruſſic acid by ſerum and the nitric acid, is a diſcovery which furniſhes a ſimpler and more œconomical proceſs than that of Scheele's, for obtaining this acid pure.

The ſerum does not decompoſe calcareous or aluminous neutral ſalts; but it acts with ſufficient energy in decompoſing metallic ſalts. It is liable to be coagulated by alcohol: this coagulum differs conſiderably from that formed in the ſerum by acids, chiefly in its ſolubility in water, as Bucquet has diſcovered. This liquid appears, therefore, from theſe reſearches, to be an animal mucilage, conſiſting of water, acidifiable oily baſes, muriate and carbonate of ſoda, with calcareous phoſphate: The roſe-coloured precipitate which I have obtained by pouring a portion of a nitric ſolution of mercury into the ſerum, appears to be owing to the latter of theſe principles. Although the liquid has ſcarce any colour, yet nitric acid, and ſtill more nitrate of mercury, produces, when poured into it, a roſe or light fleſh-colour, which I have had occaſion to obſerve in many other animal liquors. The moſt ſingular property

perty of this mucilage,—a property highly worthy of engaging the attention of physicians,—is, its being liable to become concrete by the action of fire and acids. Scheele thought this phænomenon owing to the combination of heat. Its true cause has been taken notice of above.

The clot of the blood affords, by exposure to the heat of a water-bath, an insipid water; it becomes, at the same time, dry and brittle. It affords, in the retort, an alkaline phlegm, a thick oil, of a fœtid, empyreumatic smell, and a good deal of ammoniacal carbonate. The residue which it leaves, is a spongy coal, of a sparkling metallic aspect, difficult to incinerate, and affording, when treated with sulphuric acid, sulphate of soda and sulphate of iron: there remains, after these operations, a mixture of calcareous phosphate with carbonaceous matter. Exposed to an hot atmosphere, the clot putrefies readily enough. When washed with water, this fluid separates it into two very distinct matters; the one it dissolves, deriving from it a red colour. The solution, treated with different menstrua, exhibits all the same characteristics with the serum, but is found to contain much more iron. The metal is separated by incineration, and by washing the incinerated coal, in order to carry off the saline matters. The remaining part of the lixivium, after the saline matters are carried off, is in the state of oxide of iron, of a brown colour, of considerable beauty. It is usually subject to the attraction of the magnet. Blood is thought to owe its colour to this metal. A very considerable proportion of iron has been extracted from this fluid by Messrs Menghini, Rouelle, and Bucquet.

The clot, after being washed and cleared from all the red serum which it contains, is in the state of a fibrous white matter; which it remains for us to examine.

The fibrous part of the blood is white and colourless, after being well washed: its taste is insipid. It affords, by distillation on a water-bath, an insipid phlegm, without smell, and liable to putrefaction. Even the gentlest heat hardens this fibrous matter in a singular manner. When exposed suddenly to a strong fire, it shrinks like parchment. By distillation in a retort, it affords an ammoniacal phlegm, a ponderous oil, which is thick and very fœtid, and a good deal of ammoniacal carbonate, contaminated with a portion of oil. The residual coal is not very bulky, but compact, ponderous, and easier incinerated than that of the serum. Its ashes are very white: it contains no saline matter, as it must have lost, by the washing, whatever it contained of that kind,—and no iron: it is a sort of residue of an earthy appearance, and seemingly calcareous phosphate.

The fibrous part of the blood putrefies very quickly, and with great facility. When exposed to an hot moist atmosphere, it swells, and affords a good deal of ammoniac. It is not soluble in water: when boiled in that fluid, it becomes hard, and acquires a grey colour. Alkalis do not dissolve it; but even the weakest acids combine with it: The nitric acid disengages from it a considerable quantity of azotic gas, as we are told by M. Berthollet: (I have likewise discovered, that the Prussic acid is formed, which is disengaged in vapour;) and at length dissolves it with effervescence, and the disengagement

disengagement of nitrous gas. When it ceases to emit nitrous gas, the residue is observed to contain oily and saline flakes, swimming in a yellowish liquor: This liquor affords, by evaporation, oxalic acid in crystals; and, at the same time, deposites no inconsiderable quantity of flakes, composed of a peculiar oil, and calcareous phosphate. It appears that hydrogene, carbone, and azote, which constitute the fibrous substance, are separated in different proportions, to combine with the oxigene of the nitric acid, and thus form the Prussic and carbonic acids that are disengaged in gas, and the oxalic and malic acids, that remain in solution, and are separated only by crystallization.

The fibrous matter dissolves also in the muriatic acid, which converts it into a sort of green jelly. The acid of vinegar dissolves it with the help of heat: Water, and especially alkalis, precipitate this fibrous matter from acids. This animal matter is decomposed in these combinations; and when separated, by whatever means, from acids, no longer exhibits the same properties. Neutral salts, and other mineral matters, are incapable of acting upon it. It unites with the albuminous matter, especially with that which is coloured, to form clot. This last substance, as well as the fibrous part, is totally soluble in acids; on account, no doubt, of the combination of this matter with the red serum. From this it appears, that the fibrous part differs greatly from the albuminous matter. It is more of an animal nature than that matter, being a sort of animal gluten, bearing no small resemblance to that of farina, and possessing the remarkable property of becoming concrete by rest and cooling. There is no doubt that this matter, which has

has not been sufficiently attended to by physiologists and pathologists, acts an important part in the animal œconomy. I have a considerable time since observed, that it is deposited in the muscles, and constitutes the fibrous base of those organs, and that substance which is most eminently irritable. I have concluded this substance to merit more attention than it has yet obtained, and have considered it as capable of occasioning, by its excess or deficiency, certain diseases: And I have given my reasons for entertaining such opinions, in a Memoir which is inserted among the Memoirs of the Royal Society of Medicine for the year 1783, &c. It appears that the peculiar acid which the blood affords by distillation, and which M. Chaussier has obtained from it by the action of alcohol, exists in the fibrous part of its substance. For this reason, I have proposed to call it the *cruoric acid*, if it should ever be determined to be a peculiar animal acid.

After all these ingenious discoveries concerning the nature of the blood, we are yet far from being sufficiently acquainted with all its chemical properties. We are yet ignorant of the minute difference which subsists between the serum and the fibrous part. The blood has not yet been examined in all its various states; particularly in different diseases, in which that fluid suffers considerable alterations, such as violent inflammations, the chlorosis, scurvy, &c. Physicians distinguish these alterations only by external appearances; and it is much to be wished that accurate analyses should determine their nature, in such a manner as to afford a better direction to the practitioner in the art of healing.

I have found the blood of a human foetus to differ in

three

three remarkable particulars from that of an adult. It contained no fibrous ſubſtance, ſtrictly ſpeaking, but a ſort of gelatinous matter: it did not take a bright colour from the contact of air; nor did it afford any marks of phoſphoric acid.

Rouelle has examined the blood of various quadrupeds, the ox, the horſe, the calf, the ſheep, the hog, the aſs, and the goat. He obtained from them the ſame products which the human blood affords, but in different proportions.

CHAP.

CHAP. III.

Of the Milk.

THE milk is a recrementitial humour, designed by Nature for the nourishment of the young of animals in the first period of their existence. It is of a dead white colour, a mild saccharine taste, and a smell faintly aromatic. The female of the human species, female quadrupeds, and cetaceous animals of the same species, are the only animals that afford milk. No other animal is furnished with organs for the secretion of this humonr. It was long thought, that the milk was immediately separated, by glands in the breast, from the blood conveyed into them by the numerous arteries which meet there. But the principles of which milk is known to consist, have not been hitherto proved to exist in the blood: and late discoveries in anatomy have shewn, that the breasts are furnished with a great many lymphatic and absorbent vessels, disposed in a fatty tissue; and the

the liquor which these contain is perhaps one of the chief constituent principles of milk.

Milk is very different in different animals. In woman it is highly saccharine. Cows milk is mild, and its principles are intimately united. The milk of the goat and the ass possesses peculiar virtues, and is often gently astringent. The properties of milk are liable to vary, as they commonly depend on the nature of the food with which animals are nourished.

Cows milk, which we may take as an instance, as it is so easily procured, is a compound of three different substances; serum or whey, which is fluid and transparent; butter and cheese, which have more consistency. These three parts are so mixed and suspended, as to form a sort of animal emulsion.

Milk, distilled by the heat of a water-bath, affords an insipid inodorous phlegm, susceptible of putrefaction. Exposed to a heat somewhat stronger, it coagulates like blood, as has been observed by Bucquet. When stirred and evaporated slowly, it forms a sort of saccharine extract, known by the name of *franchipane*. This extract, dissolved in water, forms Hoffman's whey. Distilled by naked fire, it affords acid, fluid oil, concrete oil, and ammoniacal carbonate. Its residual coal contains a little potash, muriate of potash, and calcareous phosphate.

Milk, exposed to an hot temperature, is liable to pass into a state of spirituous fermentation, in which it forms a sort of wine; but a considerable quantity of it must be together, in order that this alteration may take place. The Tartars prepare a spirituous liquor from mare's milk. The milk becomes quickly acid, and then

coagulates. The cheese gathers into a mass, leaving the whey separate.

When heated pretty strongly, milk experiences a singular thickening: it swells, forms a pellicle at its surface, which is renewed as fast as it is removed, until the whole of the caseous substance be separated. Messrs Parmentier and Deyeux have ascertained it to be the caseous part which forms these pellicles.

Acids have instantaneously the same effect on milk. They coagulate it; this *coagulum* is again dissolved by alkalis, especially by ammoniac. Boerhaave asserts, that milk boiled with oil of tartar becomes first yellow, and takes afterwards a blood-red colour. He is even of opinion, that it is by some such combination milk is converted in the human body into the state of real blood. Neutral salts, sugar, and gum, likewise coagulate milk, with the help of heat, as has been observed by Scheele.

To make whey, milk must be warmed with an addition of rennet, in the proportion of twelve or fifteen grains to the pint. This substance, being a mixture of milk soured in the stomachs of calves, with the gastric juice, is a fermenting substance which coagulates the caseous part. After this coagulation is effected, the whey is strained from the curds. The flowers of thistles, and artichokes, act on milk in the same way as rennet.

As to gallium, though it has got the name of milk-curdler, it does not possess that property, according to the observations of Messrs Deyeux and Parmentier. The external membrane of the stomachs of calves and birds, when dried and reduced to powder, produces the same effect on milk: a fact which proves, that

that the coagulation of this liquor is owing to the dried gaſtric juice contained in the pores of that membrane.

The ſerum or whey, prepared in this way, is turbid; it may be clarified with white of eggs and tartar. When the ſerum or whey is wanted very pure, in order to be examined, no acidulous tartarite of potaſh ſhould be intermixed with it.

Whey has a mild taſte. When prepared from new milk, it contains a ſaccharine eſſential ſalt; but it ſoon acquires a ſour taſte, in conſequence of that fermentation which takes place in it. This emotion is produced by the alteration of a mucilaginous principle contained in milk; and it is the extrication of this acid from a latent ſtate which ſeparates the whey from the other principles of which milk conſiſts. It will therefore be proper to examine the nature of the acid which is formed in ſour milk, and conſtitutes fermented whey.

It is well known, that milk left to itſelf, at a temperature of ſeventy or eighty degrees, ſuffers, in the ſpace of a few days, a fermentation, which developes an acid, and ſeparates the butter and cheeſe. The acid which is formed by this fermentation, and acquires, in the ſpace of twelve or fifteen days, all the ſtrength of which it is capable, has been examined by Scheele: We call it the *lactic acid.* The following is the proceſs by which Scheele obtained this acid pure, after attempting ineffectually to ſeparate it from ſour milk by diſtillation. This operation having afforded him only a very ſmall portion of acid, he evaporated ſour whey to an eighth part, after filtering it, to ſeparate all the caſeous mat-

ter. The animal earth he precipitated by lime-water. He diluted it with three times its weight of water; and separated the lime by oxalic acid. To ascertain whether any oxalic acid remained in it, he assayed it with lime-water; and then evaporated the liquor to the consistency of honey; and precipitated the sugar of milk, and some other extraneous substances, by mixing with it alcohol, which easily dissolves the lactic acid. Lastly, He distilled this solution; and after the alcohol was thus volatilized, the lactic acid remained pure in the retort. Scheele ascribes to this acid the following properties.

Evaporated even to a very thick consistency, it affords no crystals; it attracts moisture from the atmosphere. By distillation, it affords an empyreumatic acid, resembling the pyro-tartareous acid, a little oil, and a mixture of carbonic acid gas, with carbonated hydrogenous gas.

In union with the three alkalis, with barytes, or with lime, the lactic acid forms deliquescent salts. In combination with magnesia, it forms crystals; but these, too, attract moisture from the atmosphere. Most of these salts of milk, or alkaline and earthy lactates, are soluble in alcohol. The acid of milk does not act, in any way, on cobalt, bismuth, antimony, mercury, silver, or gold, even though assisted by a boiling heat. It dissolves zinc and iron, producing from them hydrogenous gas: the former of these salts, lactate of zinc, crystallizes; the other, lactate of iron, forms a deliquescent brown mass.

The lactic acid oxidates and dissolves lead and copper. The lactic solution of lead deposites a little sulphate of

lead;

lead; from which it appears, that this animal acid contains a ſmall portion of ſulphuric acid. Laſtly, It decompoſes acetite of potaſh: This laſt property, with the reſt here mentioned as belonging to it, ſhew the lactic acid to be different in its nature from vinegar. To theſe particulars, Scheele adds, that real vinegar may be obtained from milk, by mixing ſix ſpoonfuls of alcohol with three pints of milk, and leaving the mixture to ferment in a well-ſtopped veſſel: the gas diſengaged by the fermentation of the mixture, muſt be, from time to time, ſuffered to eſcape: at the end of a month, the milk is found changed into good vinegar: it may be then ſtrained through a cloth, and put up in bottles. The celebrated Swediſh chemiſt adds farther, that milk in a bottle, the neck of which enters a veſſel filled with the ſame liquor, undergoes, if expoſed in this condition to a heat ſomewhat ſuperior to the ordinary heat of ſummer, a fermentation which occaſions the diſengagement of a large quantity of elaſtic fluid: This fluid diſplaces the milk, ſo as nearly to empty the bottle in the ſpace of two days: The acid produced by this fermentation, which takes place without the contact of air, ſeems to owe its oxigene, the acidifying baſe of air, to the decompoſition of water.

The whey of ſweet milk, ſeparated by rennet, without ſouring, holds in ſolution a certain quantity of alkaline ſubſtance, known by the name of ſalt or ſugar of milk. Although Kempfer aſſerts, that the Brachmans have a proceſs for preparing this ſalt, it appears that Fabricius, Bartholet or Bartholdi, an Italian phyſician, firſt mentioned it to the world, in the year 1619. Etmuller Teſti, Werloſchnigg, Walliſnieri, Fickius, and Cartheuſer,

 have

have succeſſively written concerning it, and deſcribed proceſſes for its preparation. Meſſrs Vulgamoz and Lichtenſtein have given very particular accounts of the art of extracting this ſaline ſubſtance, which is prepared in the great way in different places in Switzerland. They there evaporate whey, obtained from milk by ſkimming and coagulating it with rennet, till it be reduced to the conſiſtency of honey: This ſubſtance, put into moulds, and dried before the ſun, forms ſugar of milk in tablets: theſe are diſſolved in water, clarified with white of eggs, and evaporated to the conſiſtency of a ſyrup; and then the liquor is cryſtallized in the cold: white cryſtals are formed in it, in rhomboidal parallelipipeds; the mother-water depoſites yellow and brown cryſtals, which are purified by ſucceſſive ſolutions. M. Lichtenſtein has examined and analyſed the different ſugars of milk that are ſold in Switzerland at different prices; and has particularly diſtinguiſhed, 1. *The ſweet ſugar of milk*, which is extracted from ſweet purified whey: 2. *The aceſcent ſugar of milk*, obtained from ſour whey: 3. Sugar of milk, *rendered impure by a mixture of fat particles*, which, according to him, ſeparates in the firſt cryſtallization: 4. Sugar of milk, *mixed with oil and common ſalt*, which is laſt cryſtallized: 5. Sugar of milk, *mixed with fat particles, common ſalt, and ſal ammoniac*; it is glutinous and moiſt; treated with fixed alkali, it affords ammoniac: 6. Laſtly, Sugar of milk, mixed with all the above-mentioned ſubſtances, *and likewiſe with extractive and caſeous matter*; this laſt ſugar is of the conſiſtency of honey; it is liable to turn rancid, and is acrid and diſagreeable.

Pure

Pure ſugar of milk taſtes, in a faint degree, like ſugar, inſipid, and ſomewhat earthy. By repeated ſolutions, there is always ſo much of it loſt. It diſſolves in three or four parts of hot water: It affords, by diſtillation, the ſame products as ſugar, according to Meſſrs Rouelle, Vulgamoz, and Scheele. The firſt of theſe chemiſts obtained, by burning, a pound of this ſalt, from 24 to 30 grains of aſhes; of which three fourths were muriate of potaſh, and the remaining fourth part carbonate of potaſh. On a burning coal, ſugar of milk melts, ſwells, gives out a ſmell of caramel, and burns like ſugar. Theſe properties afforded reaſon for thinking, that this ſalt would, like ſugar, afford oxalic acid, if treated with nitric acid. Scheele's experiments have confirmed this conjecture: But he obſerves, that a much more conſiderable proportion of ſpirit of nitre is neceſſary for this purpoſe, than to produce oxalic acid from common ſugar; and that 4 ounces of ſugar of milk afford 5 drams of oxalic acid: And he has farther diſcovered, that the reſidue of ſugar of milk that has been treated with nitric acid, when diluted in water, and filtrated, in order to the evaporation and cryſtallization of the oxalic acid, leaves on the filter a white powder, which he found to poſſeſs the characteriſtics of a peculiar acid, different from the former. This we denominate the *ſaccho-lactic acid*. The following are its properties, as obſerved by Scheele:—

This acid is in the form of a white granulated powder. Two drachms of this ſalt, in a ſtate of conſiderable purity, on being expoſed to heat in a glaſs-retort, melted, ſwelled, and turned black. There was ſublimated from this matter, a brown ſalt, the ſmell of which

was a compound of the smell of benzoin with that of amber, and which weighed 35 grains. This sublimate was acid, soluble in alcohol, but not so easily as in water, and burned on the coals. In the receiver, there was found a brown liquor, which possessed none of the characteristics of an oily substance. In the retort, there remained 11 grains of coaly matter. Both carbonic acid and hydrogenous gas were disengaged during the distillation. The saccho-lactic acid is scarce soluble in water; for an ounce of boiling water dissolves only six grains of it; and even of that quantity, a fourth part is precipitated by cooling.—M. de Morveau says, that this acid effervesces with an hot solution of carbonate of potash. Saccho-lacte of potash, crystallized by cooling, was dissolved in eight times its weight of hot water, and crystallized anew by the cooling of the liquor. Saccho-lacte of soda is susceptible of crystallization, and only five parts of water are requisite to dissolve it. This acid likewise combines with ammoniac; but heat deprives the neutral salt thus formed of its volatile base. With barytes, aluminous earth, magnesia, and lime, the saccho-lactic acid forms salts which are almost insoluble. It acts with little energy on metals; with their oxides it forms neutral salts, which are scarce soluble. It precipitates nitrates of mercury, lead, and silver; as also muriate of lead.

When Scheele first made this discovery, he thought, that the white powder deposited by the oxalic acid, obtained from sugar of milk by the nitric acid, was nothing but calcareous oxalate, the formation of which was owing to lime which might possibly be contained in this animal salt; but he was soon undeceived, when, on

pouring

pouring a small portion of pure oxalic acid into a solution of sugar of milk, he found the mixture to afford no precipitate. Yet M. Hermstadt, who, in Crell's Journal, has given two Memoirs on sugar of milk, in the second of which he enters into a particular examination of this earthy acid; thinks, notwithstanding Scheele's experiments, that it must be a compound of oxalic acid and lime with a fat matter. But M. de Morveau, examining, with his usual accuracy, the experiments of this chemist, and comparing them with those of Scheele, has shewn, in the new *Dictionnaire Encyclopædique*, that M. Hermstadt has not accomplished his object, and that even the results of his experiments rather confirm than contradict the discoveries of the Swedish chemist. M. de Morveau has himself made several ingenious experiments, which concur to establish the same fact.—To these particulars we may add, that the oxalic and the saccho-lactic acids do not exist ready-formed in sugar of milk; and that this salt contains only the bases which attract oxigene, or the acidifying principle from the nitric acid. We may farther observe, that new experiments may one day, perhaps, shew the saccho-lactic acid to be nothing but a modification of some other vegetable acid; for every thing tends to prove, that the principles of whey have belonged originally to the vegetables with which the animals that afford it are nourished.

Baron Haller represents sugar of milk as existing in the following proportions, in the milk of the following animals:

Four ounces of sheep's milk afford from 35 to 37 grains of sugar of milk:

The

The ſame quantity of goat's milk	-	from 47 to 49
———— of cow's milk	-	from 53 to 54
———— of woman's milk		from 58 to 67
———— of mare's milk	-	from 69 to 70
———— of aſs's milk	-	from 80 to 82

Rouelle has obſerved, that after the ſugar of milk is extracted from the whey of cow's milk, it cools into a ſort of jelly; and accordingly believes it to contain gelatinous matter.

The cheeſe, or caſeous part of milk, is formed into a maſs, and ſeparated from the other parts of the liquid, by the action of fire, by the acid fermentation to which milk is liable, and by the intermixture of acids. This matter, when well waſhed, is white and ſolid, like the albumen of the blood, when coagulated by heat. A gentle heat hardens it. By diſtillation on a water-bath, it affords an inſipid phlegm, ſubject to putrefaction.

Dried cheeſe affords, by diſtillation in a retort, an alkaline phlegm, a ponderous oil, and a conſiderable proportion of ammoniacal carbonate. Its coaly reſidue is denſe, very difficult to incinerate, and incapable of affording fixed alkali. When treated with nitric acid, it is found to contain lime and phoſphoric acid.

Cheeſe putrefies in a hot temperature: It ſwells, diffuſes a noiſome ſmell, becomes half-fluid, and, in conſequence of the diſengagement of a ſtrong-ſmelling and highly mephitic gas, which with difficulty eſcapes from this viſcid matter, is covered over with froth.

Cheeſe is not ſoluble in cold water; and hot water hardens it. Scheele has obſerved, that when it has been

precipitated

precipitated by an acid, boiling water becomes capable of diſſolving a part of it.

The alkalis diſſolve it: ammoniac eſpecially, when a few drops of it are poured into milk coagulated by an acid, cauſes the *coagulum* in a ſhort time to diſappear.

Concentrated acids alſo diſſolve cheeſe. The nitric acid diſengages azotic gas from it. The vegetable acids do not diſſolve it in any ſenſible degree. The ſolution of cheeſe in the mineral acids is precipitated by alkalis; of which, however, too great a quantity diſſolves the precipitate again.

The neutral ſalts, eſpecially muriate of ſoda, retard the putrefaction of this ſubſtance. Alcohol coagulates it.

From theſe particulars it appears, that cheeſe is a ſubſtance, like the albumen of the blood.

Butter is in part ſeparated from milk by reſt, and collected on the ſurface. But being, in this ſtate, mixed with a good deal of ſerum and caſeous matter, it is ſeparated from theſe matters by rapid agitation. This is the art of making or churning butter.

In the ſeparation of the cream, and in the formation of the butter, a phænomenon takes place, which has not hitherto met with that attention from philoſophers which it deſerves. The contact of air, and the abſorption of oxigene, are neceſſary to the production of butter, and to its being obtained in a ſolid form. It is not completely formed in the milk. In proportion as it collects on the ſurface, it abſorbs oxigene from the atmoſphere, and ſeparates itſelf from the other principles of the milk in conſequence of its ſolidity, and from its now aſſuming the nature of a concrete oil. Hence it cannot be

be disengaged by agitation till after a certain period; and till such time as it has absorbed the requisite quantity of oxigene, it does not constitute a mass, nor does it take a consistence by the strongest agitation.

The serum which swims over churned butter, still retains a portion of this oily substance; it is yellow, sour, and fat, and is called *butter-milk*. What is called *cream*, is a mixture of cheese and butter, skimmed off milk. It is much more difficult to digest than pure milk. A considerable agitation will reduce this substance into froth: in this state, it is called *whipped cream*.

Pure butter is soft and concrete, of a golden yellow colour, sometimes higher, sometimes lighter, and of an agreeable sweet taste. By a gentle heat, it melts; and by cooling, becomes solid. When distilled on a water-bath, it affords an almost insipid phlegm. In the retort, it affords an acid, of a very strong pungent smell; at first, a fluid oil; and afterwards, a concrete coloured oil, of the same pungent smell with the acid. When these products are rectified, the oil is rendered as fluid and volatile as essential oils. The residual coal is but very scanty. The acid which butter affords by distillation appears to be of the same nature with that which is extracted from grease; of which we will hereafter speak, under the name of the *sebacic acid*. It may also be extracted in neutral salts, by the application of lime, potash, or soda.

Butter, in a hot temperature, easily becomes acid and rancid. Its acid is then disengaged from a latent state, and is found to have a disagreeable taste. Water and alcohol, by dissolving the acid, reduce the butter nearly

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to its former ſtate. Fixed alkali diſſolves butter, and forms a real ſoap with it.

From this detail of particulars, it appears, that butter is an oily ſubſtance, of the ſame nature with concrete vegetable fixed oils.

Freſh butter is ſweet, cooling, and relaxing; but it eaſily becomes ſour, and agrees but with few ſtomachs. Brown butter, the acid of which is developed, is one of the moſt unwholſome articles of food, and the moſt difficult to digeſt, that can be made uſe of.

Milk is an aliment both agreeable and uſeful in a great many caſes. It is even one of the moſt valuable medicines that can be preſcribed. In diſeaſes affecting the ſkin or joints, ſuch as the ring-worm, the gout, &c. it ſweetens the acrid humours. It even heals up ſome ulcers that are not of a very malignant ſort. It may be impregnated with the aromatic parts of plants: it is then an excellent medicine for the phthiſis pulmonaris. All ſtomachs are not fit for digeſting milk: It is generally troubleſome to people who are liable to the heart-burn, from too much acidity in the primary paſſages: It ſhould be almoſt always adminiſtered with great caution. Milk rendered medicinal, by feeding the animal which affords it on certain ſubſtances for that purpoſe, is often uſed with ſucceſs.

The milk of different animals poſſeſſes different virtues. Woman's milk is ſweet, and highly ſaccharine, and produces very happy effects in the caſe of a maraſmus. Aſs's milk is ſucceſsfully uſed for the phthiſis pulmonaris, and the gout; it commonly relaxes. Mare's milk is nearly of the ſame quality with that of the aſs. Goat's milk is ſerous and gently aſtringent. Cow's milk is

thicker

thicker, richer, more nouriſhing: it is likewiſe more difficult to digeſt; and it is frequently neceſſary to dilute it with water, or ſome aromatic infuſion, eſpecially if it be found difficult to digeſt, or if it occaſion looſeneſs or vomiting.

Milk is likewiſe employed externally as emollient and relaxing. It relieves pains, it ripens abſceſſes, and accelerates their ſuppuration. It is applied warm, incloſed in a bladder, to the parts affected.

THE END OF VOLUME THIRD.